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SOARD RADAR - AN/APQ-93

Engineering Review Meeting

of

3 and 4 January 1963

Charts and Notes Used For Presentation

by

Westinghouse Electric Corporation

Air Arm Division

Baltimore 3, Maryland

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25 YEAR RE-REVIEW

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AGENDA

Engineering Review Meeting

3 and 4 January 1963

I. Design Evaluation — Mooney

1. System Performance
   a. Stability
   b. Resolution - Az. and Range
   c. Transfer Characteristics
   d. S/N
2. Analytical Tasks
3. System S/N
   a. Predicted S/N
   b. Possible Improvements
4. System Resolution

II. Motion Compensation — Raven - Wheeler

1. Motion Compensation System
   a. Deliverable System
   b. F-101 Installation
2. Analysis of Operation in F-101 Without Motion Compensation
3. Predicted Operation in F-101
4. Predicted Future Operation

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III. Antenna Development — Wheeler

1. Results to Date
2. Predicted Performance
3. Possible Improvements

IV. System Units — Dempsey

1. Resonant Ring Improvement
2. New Transmitter - Crossed Field Amplifier
    a. Performance
    b. Schedule

V. Flight Test Program — Stinson

1. Comparison of Flights - S-11 and S-33
2. Flight Test Schedule
3. Detail Flight Plans - Flights S-34, S-35, S-36

VI. Environmental Test Program — Stinson

1. Test Schedule
2. Test Procedures

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I. DESIGN EVALUATION

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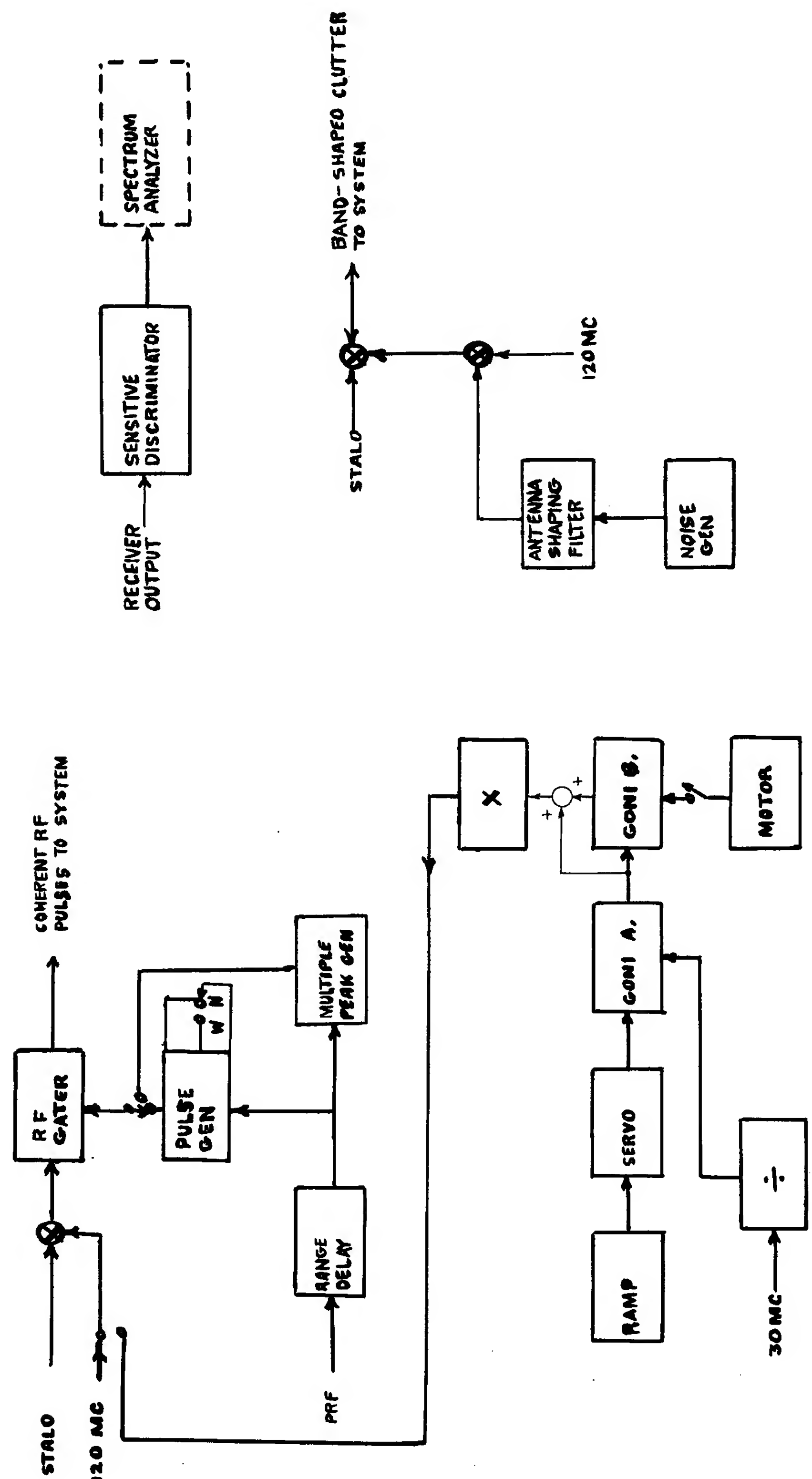
TEST SET



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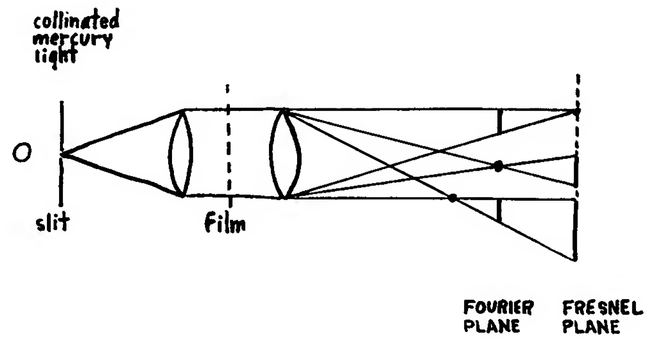
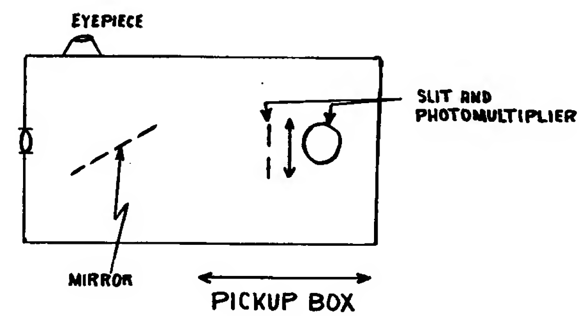
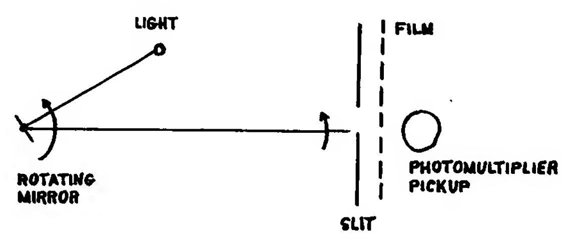
FILM EVALUATORS







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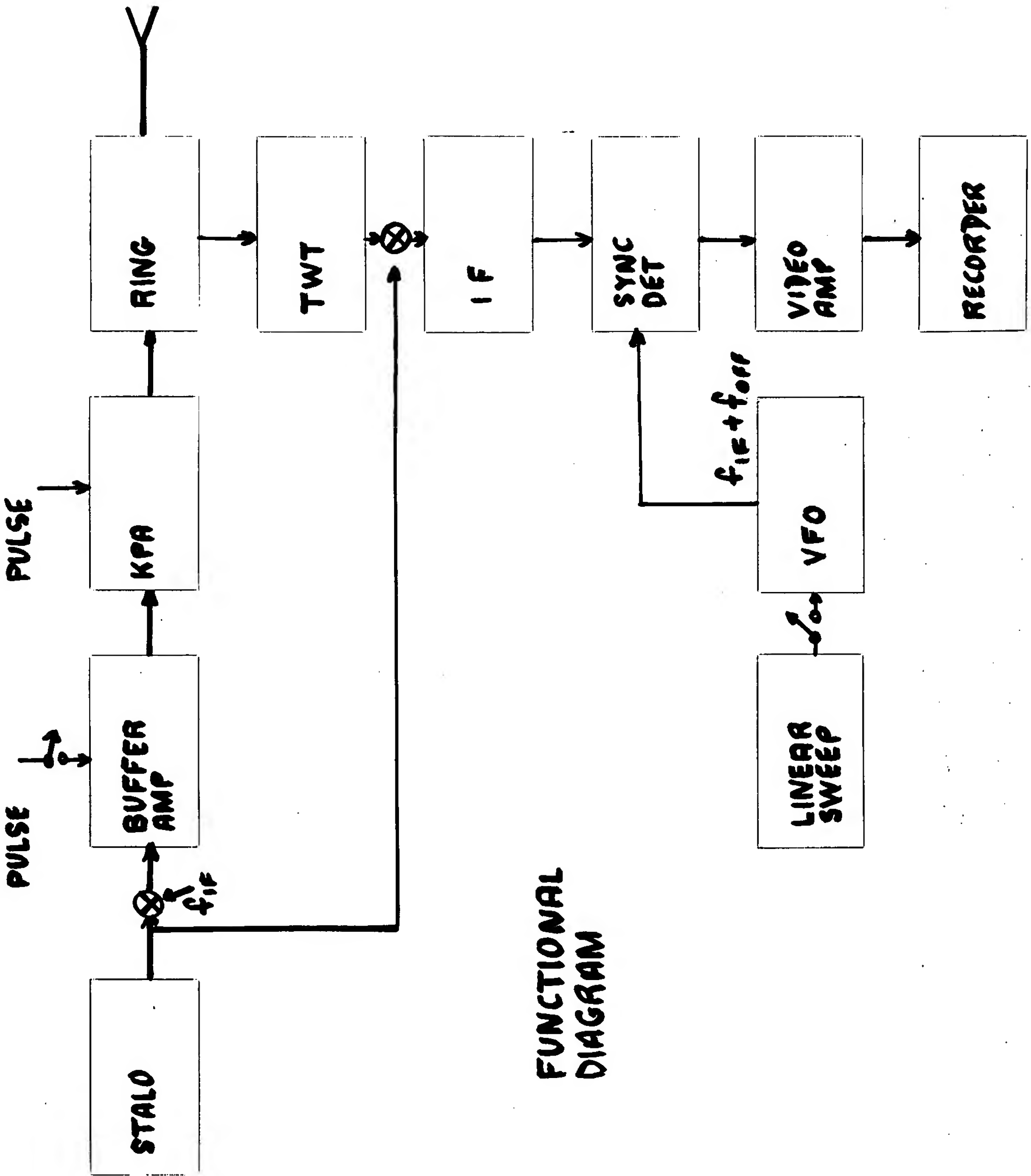

FUNCTIONAL DIAGRAM

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DESIGN EVALUATION RESULTS

I. PHASE STABILITY
  a. RECEIVER AND REFERENCES WITH DISCRIMINATOR AND SPECTRUM ANALYZER
  b. STALO WITH STALO TESTER
  c. RECORDER AND RECEIVER WITH SINE WAVE AND FM PATTERNS
  d. TEST SET WITH PHASE DETECTOR
  e. KPA WITH PHASE DETECTOR
  f. RING WITH PHASE DETECTOR
  g. STALO WITH CORNER REFLECTOR AND PHASE DETECTOR
  h. WHOLE SYSTEM (EXCEPT TRANSMITTER) AND TEST SET FM PATTERNS
  i. WHOLE SYSTEM INCLUDING TRANSMITTER WITH CORNER REFLECTOR FM PATTERNS
  j. CORRELATION OF DIFFERENT PARTS OF FM
  k. PULSE JITTER WITH JITTER TESTER

II. AZIMUTH RESOLUTION
  a. CORRELATOR WITH 2 SINE WAVE AND FM PATTERNS
  b. SINE WAVES THROUGH WHOLE SYSTEM, RECORDED, CORRELATED
  c. FM PATTERN THROUGH WHOLE RECEIVER; CORRELATED; RESOLUTION
  d. FM PATTERN, WHOLE SYSTEM FROM CORNER REFLECTOR
  e. IMPROVEMENTS TO CORRELATOR
  f. IMPROVEMENTS TO RECORDER
  g. RECEIVER LOW FREQUENCY CUT-OFF

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III. RANGE RESOLUTION
- a. RECEIVER WIDTH AND SHAPE WITH TEST SET
- b. RESPONSE SHAPING WITH RC AND RECORDER
- c. MULTIPLE PULSES WITH RECEIVER, RECORDER
- d. RECEIVER LOW-FREQUENCY CUT-OFF

IV. TRANSFER CHARACTERISTICS
- a. $\sqrt{\text{TRANSMISSION}}$ VS. GRID VOLTAGE
- b. SINE WAVE RECORDING HARMONICS VS. GRID BIAS
- c. RECORDER-CORRELATOR DYNAMIC RANGE
- d. FM PATTERNS FOR IF AND VIDEO LIMITING

V. SIGNAL/NOISE
- a. NOISE RECORDINGS
- b. SINE AND FM PATTERNS WITH NOISE

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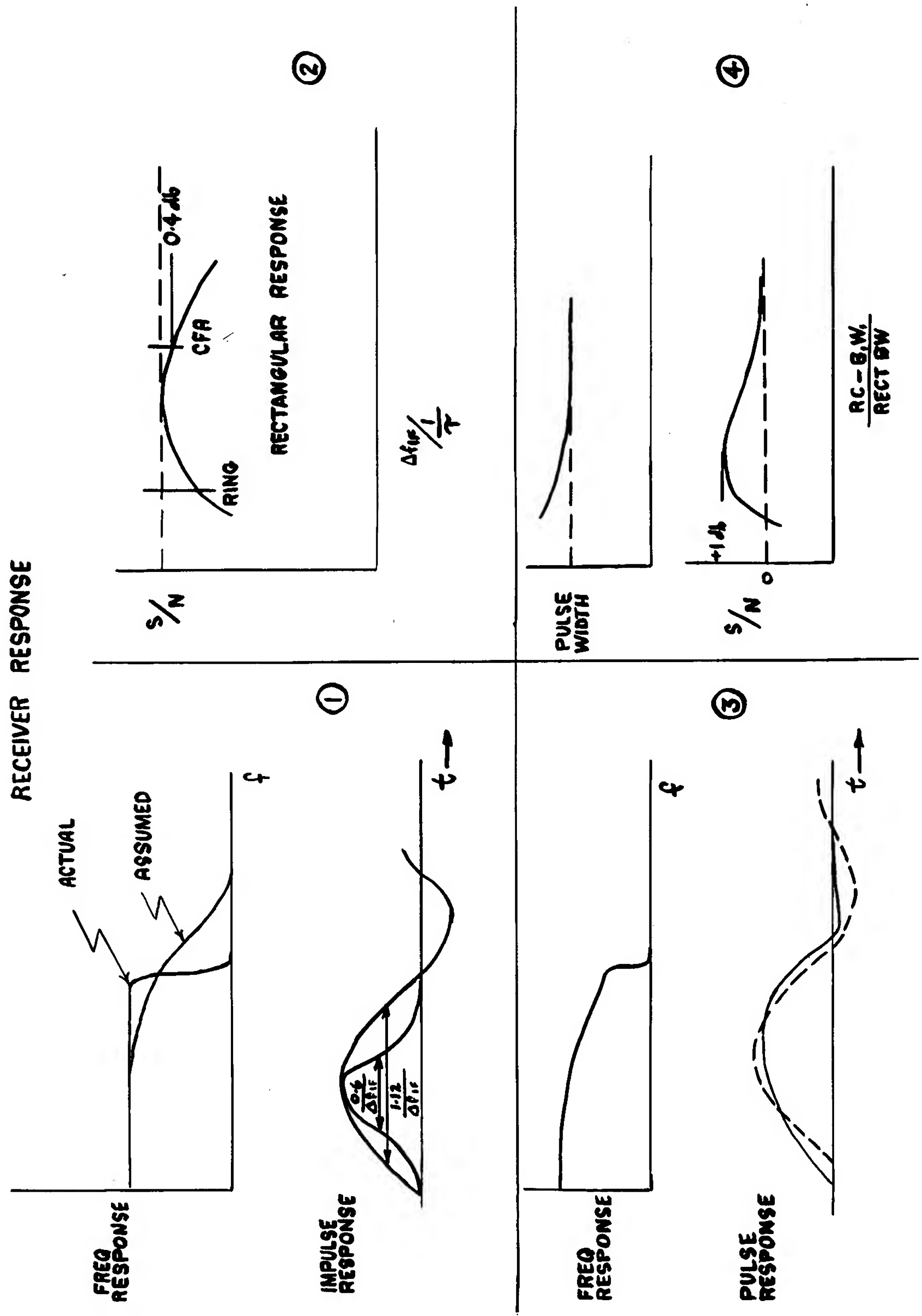

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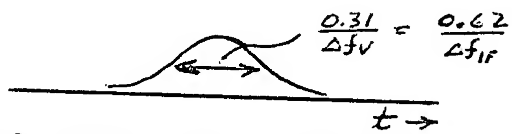
Receiver Response

Original analysis assumed:

a. Gaussian shaped frequency response of receiver.

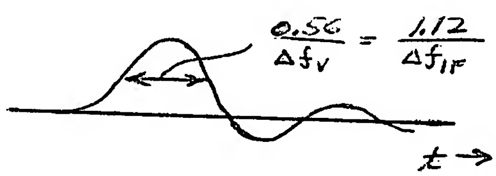
b. Gaussian shaped transmitter pulse.

Impulse response of Gaussian receiver has pulse width at the -6 db points of $\dfrac{0.31}{f_{video\ (3\ db)}}$ or $\dfrac{0.62}{f_{IF\ (3\ db)}}$, and is gaussian:



For actual system, both assumptions a and b turned out to be poor choices. The pulse is much more nearly rectangular, and the receiver response is much more nearly rectangular also.

Receiver as mechanized has response determined almost entirely by IF, and is 7 cascaded 2-pole maximally flat networks, with overall -3 db bandwidth of 60 mc centered at 120 mc. Response for 8 -two pole networks evaluated on computer:



Response is nearly twice as wide as for gaussian receiver, and has overshoot. This result is almost exactly the same as for a rectangular IF frequency response, which should be no great surprise, since receiver has -6 x 14 = -84 db/octave cutoff. Receiver response is then 20 nanoseconds for an impulse, compared to 10 nanosec transmitter. Seems clear that:

a. receiver should be widened if plan to use 10 nsec.

b. response should be shaped to reduce ringing.

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Enclosed photographs show measured response for both 10 and 30 nanosecond pulses, at the IF and the video amp outputs. Also shown is comparison between:

a. measured output for 10 nanosec pulse.

b. measured output for 30 nanosec pulse.

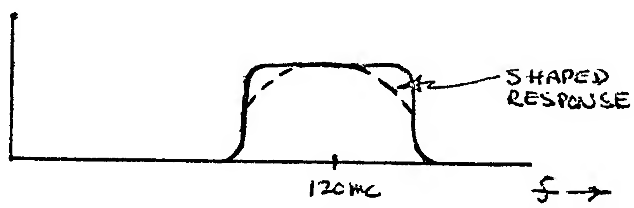
c. theoretical output for 8 two pole networks for impulse.

d. theoretical output for rectangular filter for impulse.

Good agreement is seen.

Since plan to go to 30 nanosecond pulse for cross-field amplifier, receiver bandwidth should be at least adequate as is. Figure shows effect of receiver bandwidth on S/N, for a rectangular filter and rectangular pulse, both of which are good approximations to existing case. Points on curve indicate "ring" (10 nanosec pulse) and "CFA" (30 nanosec). The present receiver is very near optimum for S/N for a 30 nanosec pulse (0.4 db loss). Next figure shows effect of bandwidth on resolution, by comparing receiver output pulse width to input pulsewidth. Could tolerate narrower receiver for 30 nanosec pulse without much resolution loss.

One way to narrow receiver is by shaping it with a single L-C (or RC at video) filter to round-off response and thereby reduce ringing.



Photographs show effect of adding RC filter to video amp output having 20 mc, 12 mc, and 5 mc 3 db bandwidth. Very little is lost in resolution or amplitude, but side lobes are virtually eliminated for the 12 mc filter. Of course since noise is reduced by the filter also, the S/N should actually be improved slightly.

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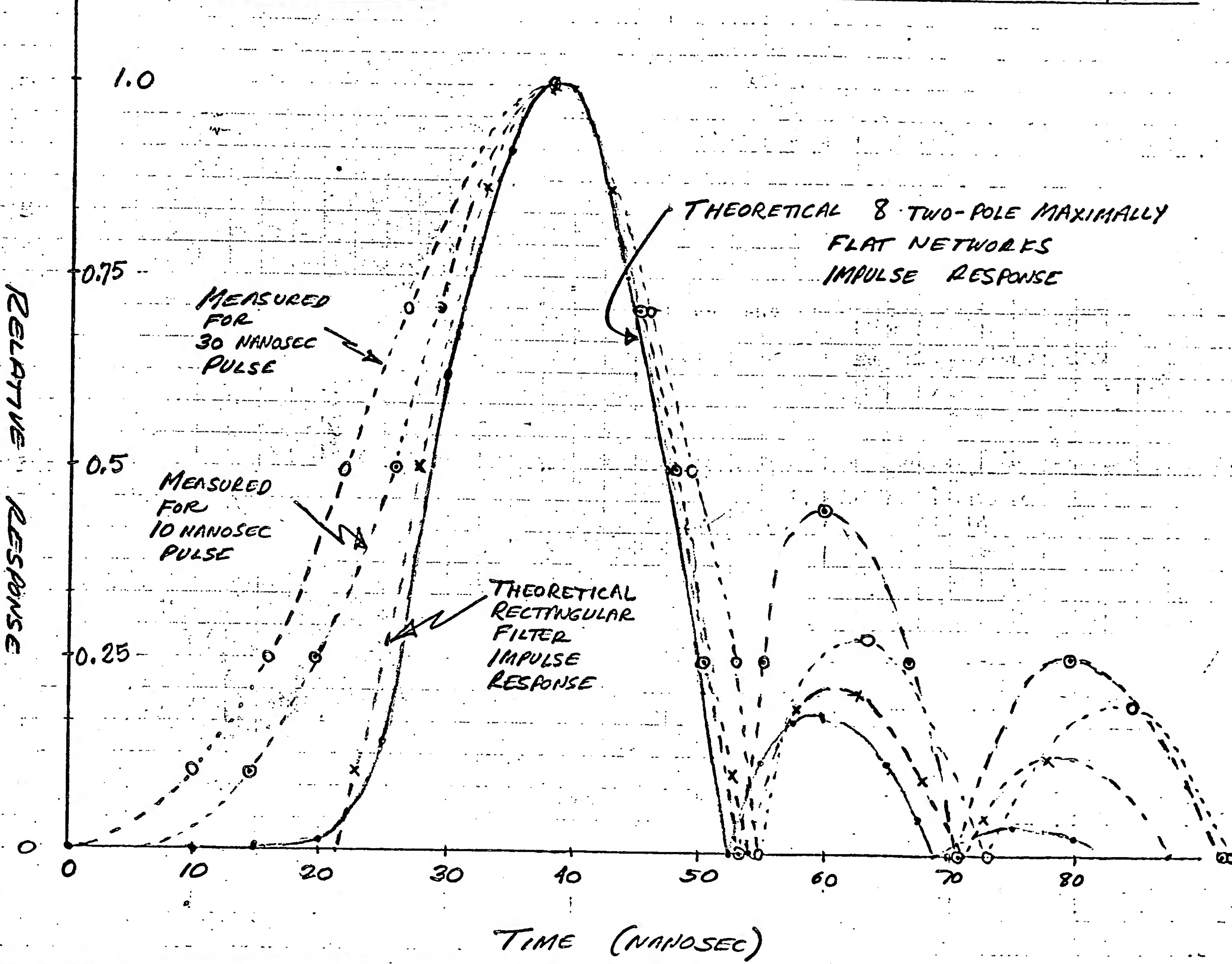
COMPARISON OF MEASURED AND CALCULATED RESPONSE



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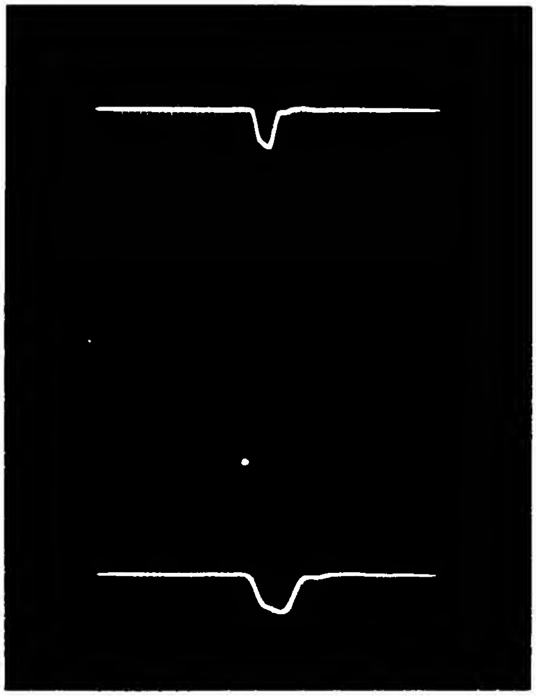
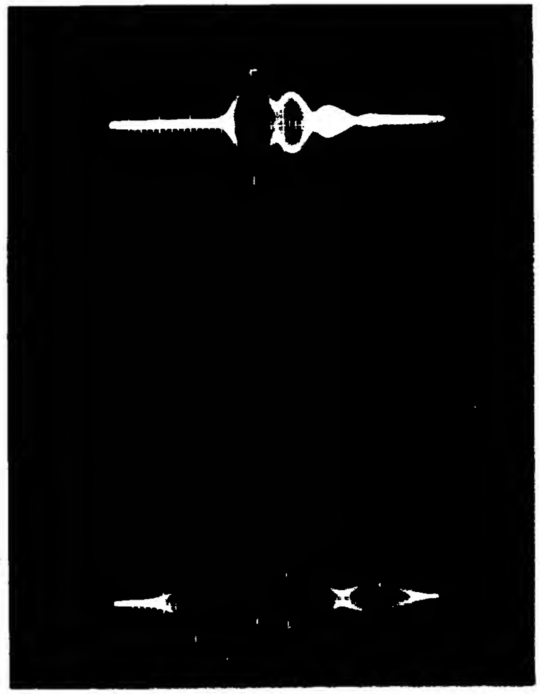
Receiver Response for 10 Nanosecond Pulse

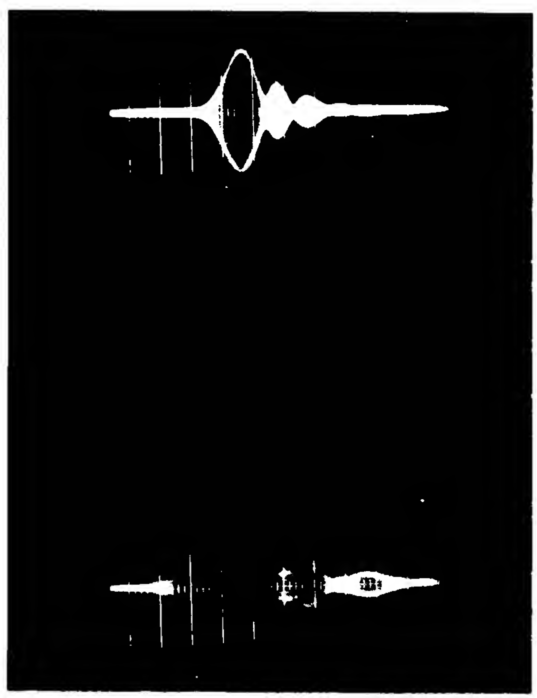
Detected RF Input Pulse



IF Amplifier Output Pulse
(Bipolar)



Video Amp Output Pulse
(Bipolar)



All pictures:

upper half at 20 nanosec/cm

lower half at 10 nanosec/cm

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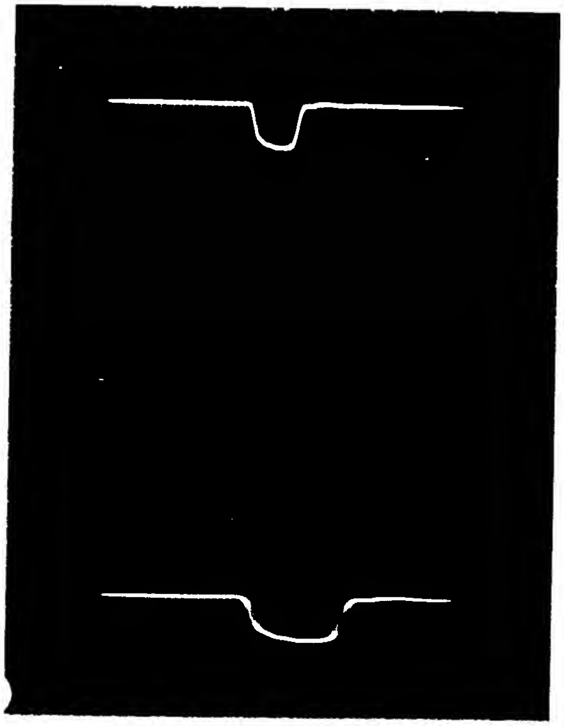
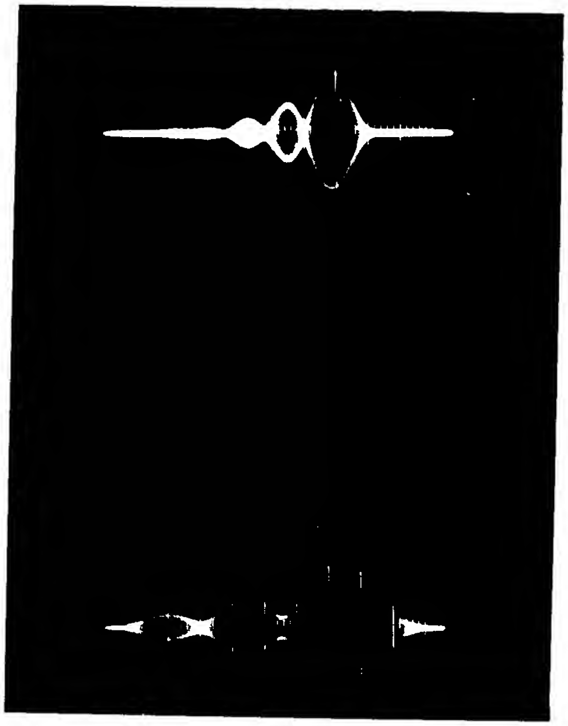
Receiver Response for 30 Nanosecond Pulse

Detected RF Input Pulse



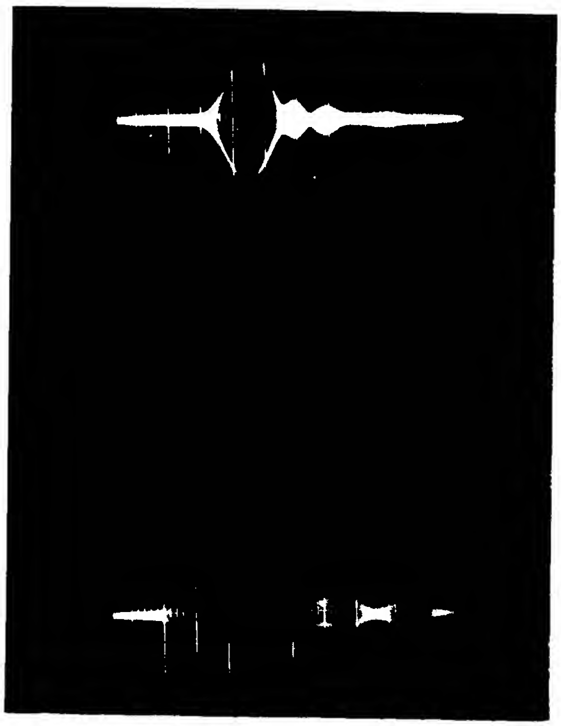
IF Amplifier Output Pulse
(Bipolar)



All pictures:

upper half at 20 nanosec/cm

lower half at 10 nanosec/cm



Video Amp Output P:
(Bipolar)

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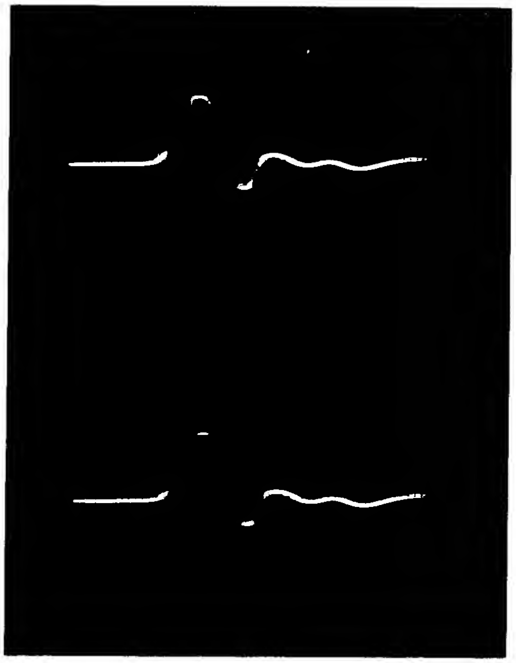
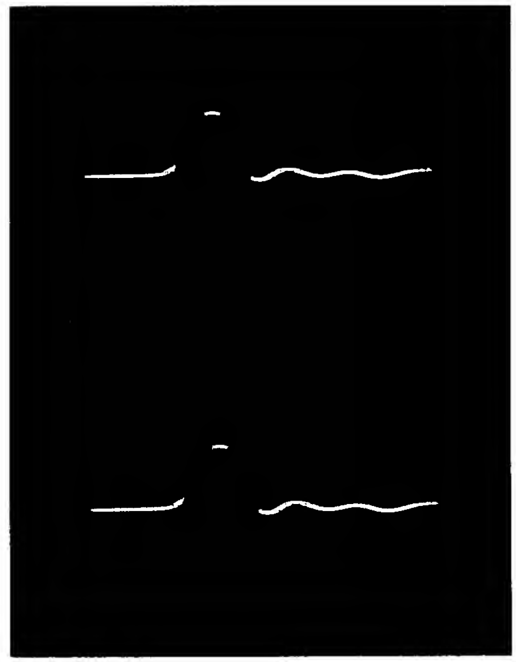
EFFECT OF RESPONSE SHAPING
(all photos: 20 nanosec/cm)

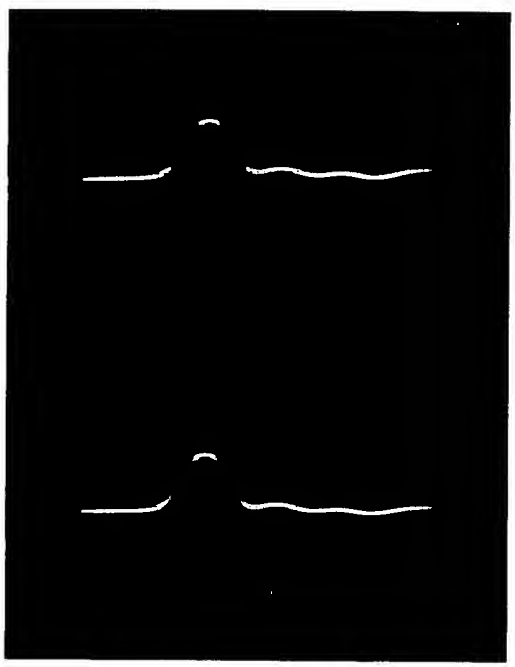
No Shaping .



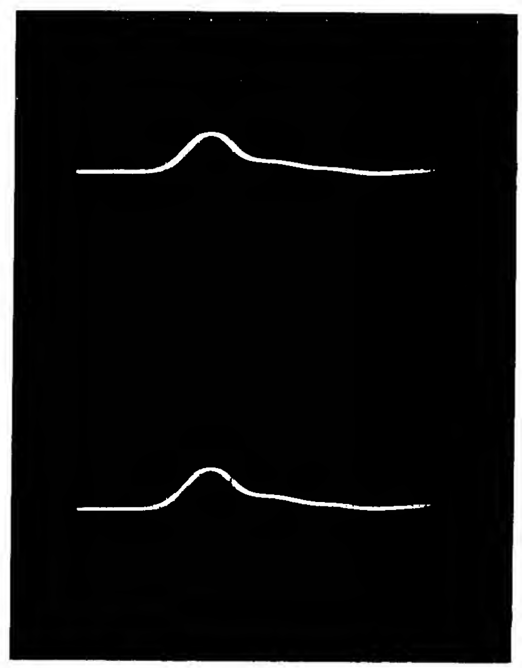
20 mc Filter



12 mc Filter



5 mc Filter



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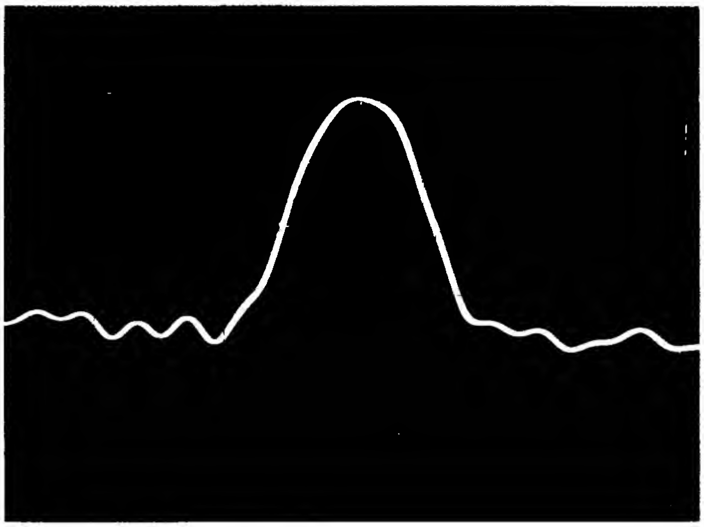
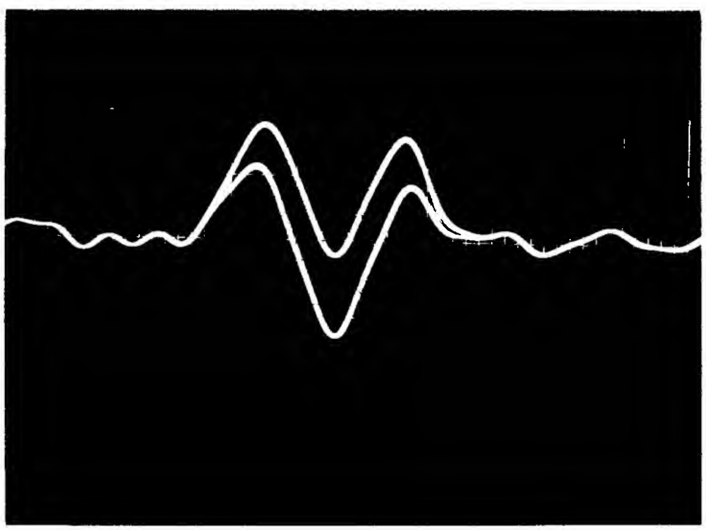
CROSS-FIELD AMPLIFIER WAVEFORMS



AMPLITUDE DETECTED R-F PULSE



PHASE DETECTED R-F PULSE (REFERENCE PHASE-SHIFTED BY 20° TO SHOW PHASE JITTER SENSITIVITY OF 15°/CM)

(BOTH PICTURES ARE 1 SECOND EXPOSURE, COMPARABLE TO RADAR DWELL TIME)

CROSS-FIELD AMPLIFIER STATUS

MEASURED RESULTS:

PEAK POWER:	600 KW
PULSE WIDTH (-3 db)	40 NANOSEC
PULSE-TO-PULSE PHASE DEVIATION:	1.5° PK-PK
INTRAPULSE PHASE VARIATION:	±30°
GAIN (OVERDRIVEN CONDITION):	16 db

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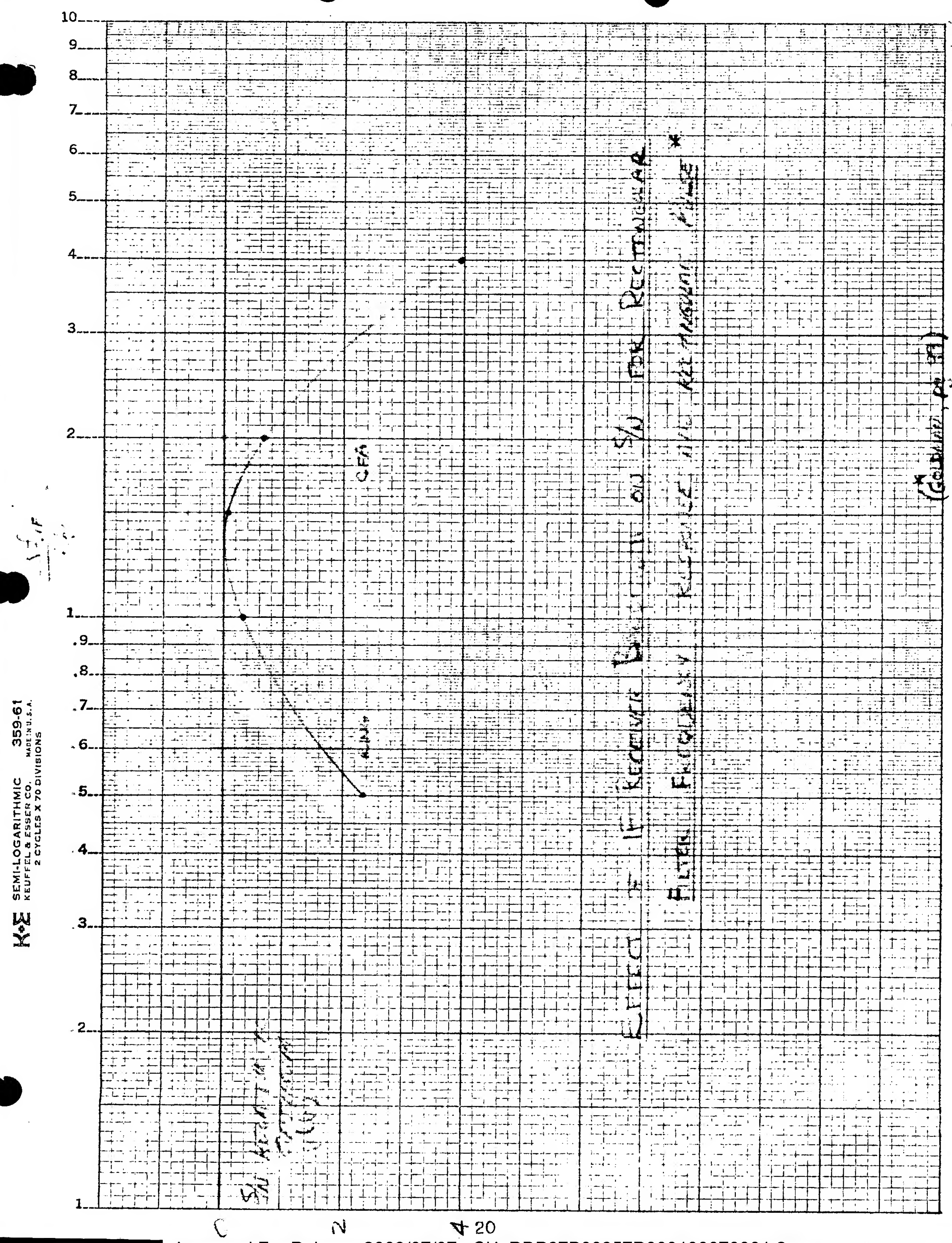

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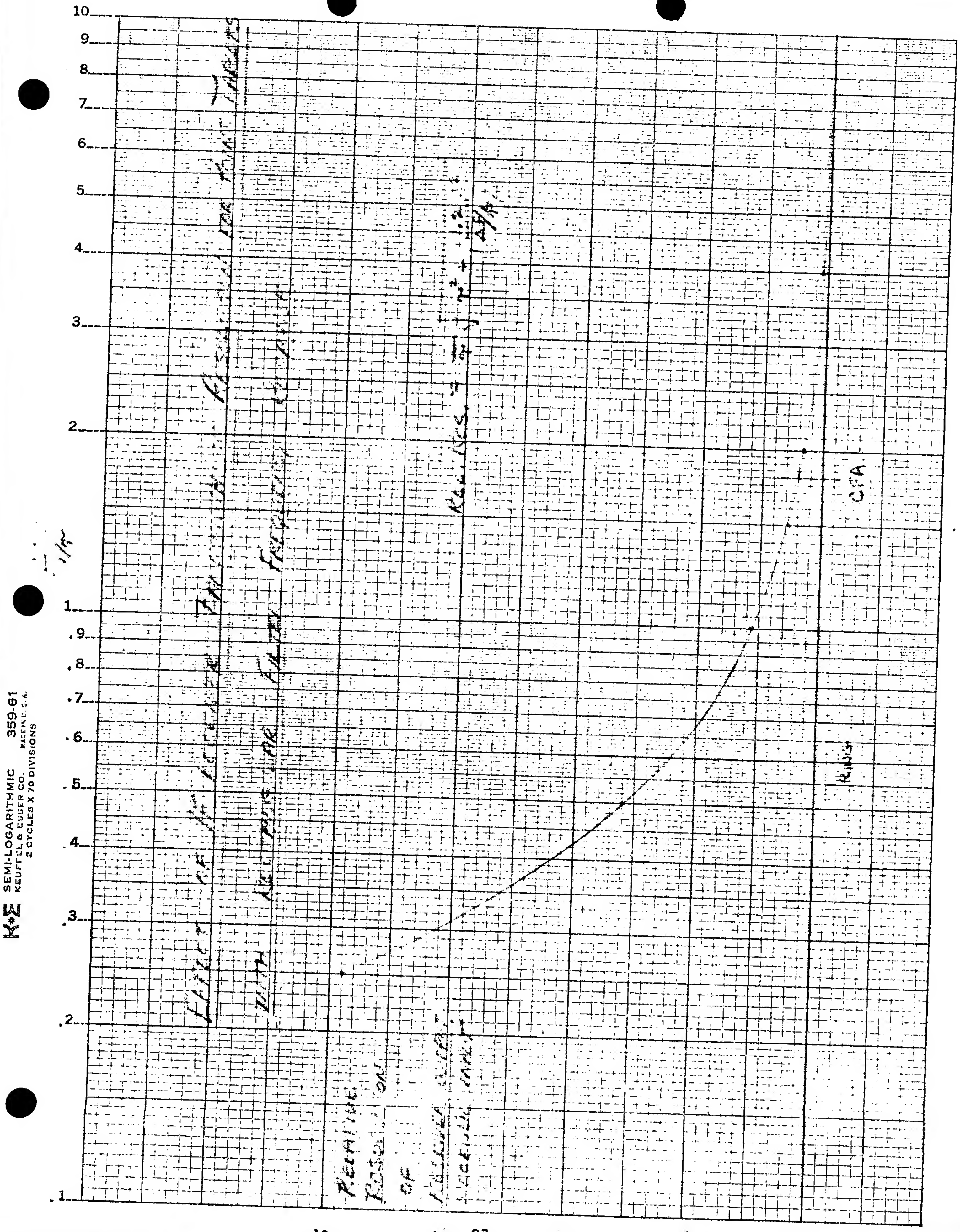

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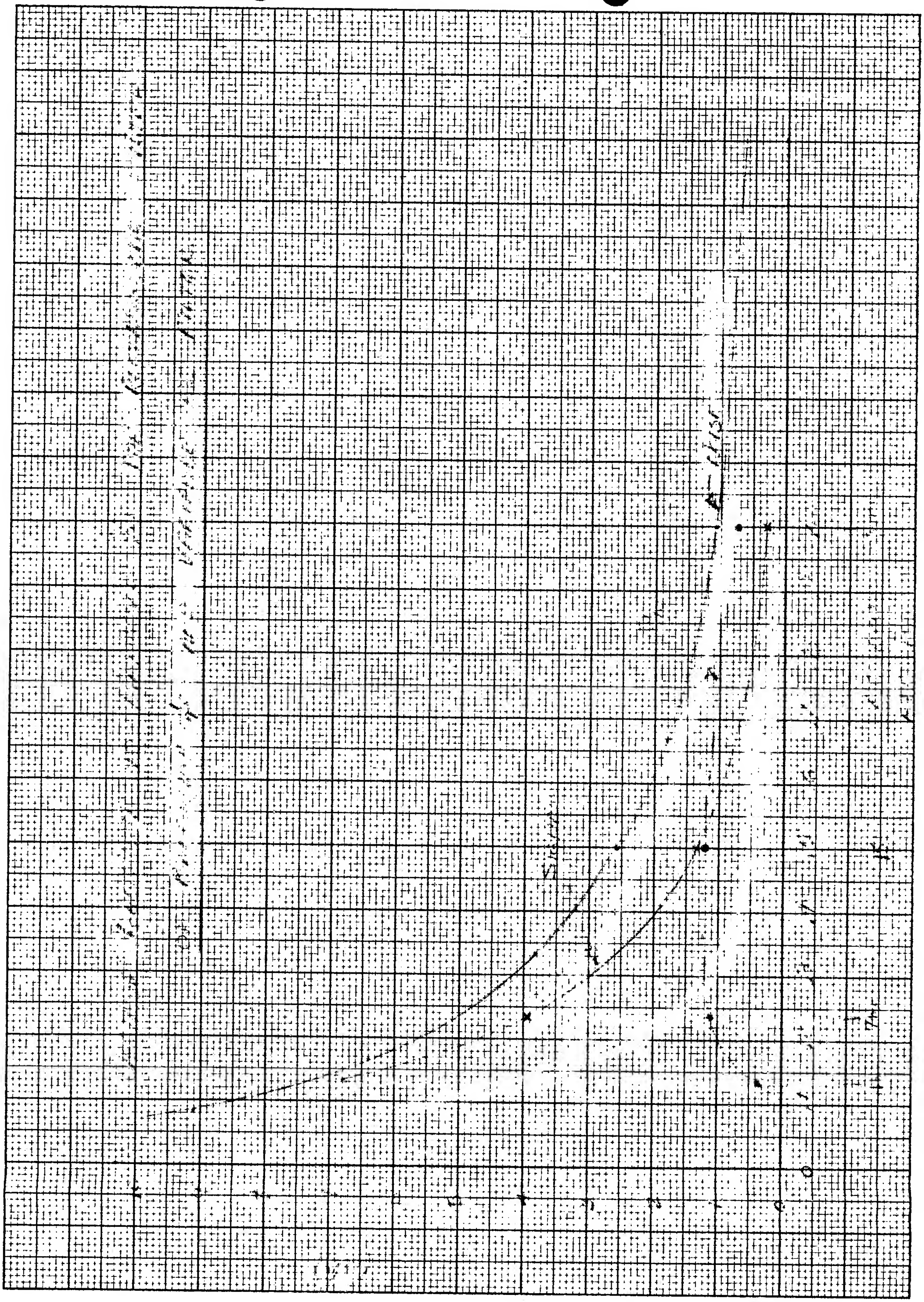

K&E 10 X 10 TO THE ½ INCH 359-11
KEUFFEL & ESSER CO.

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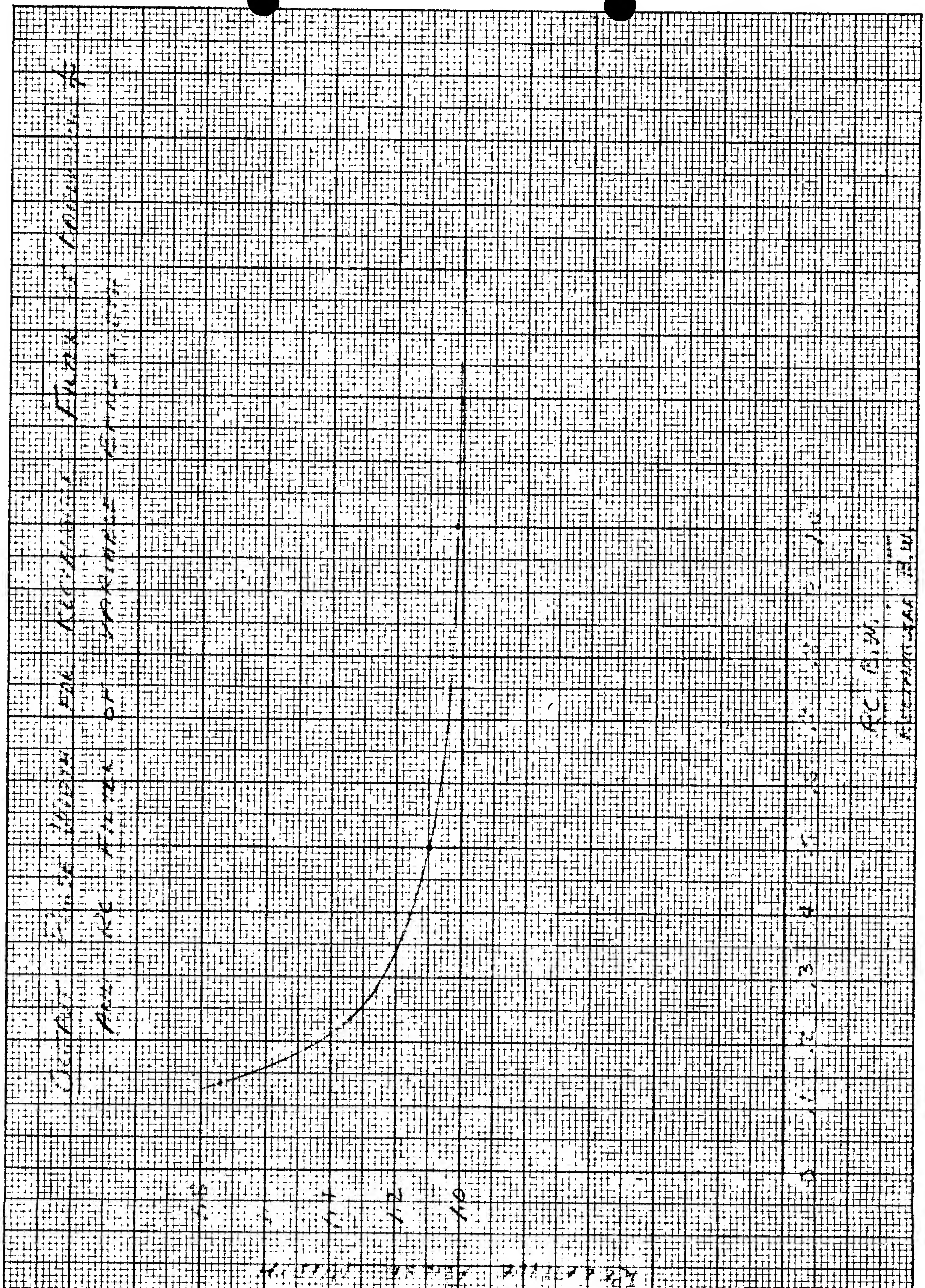

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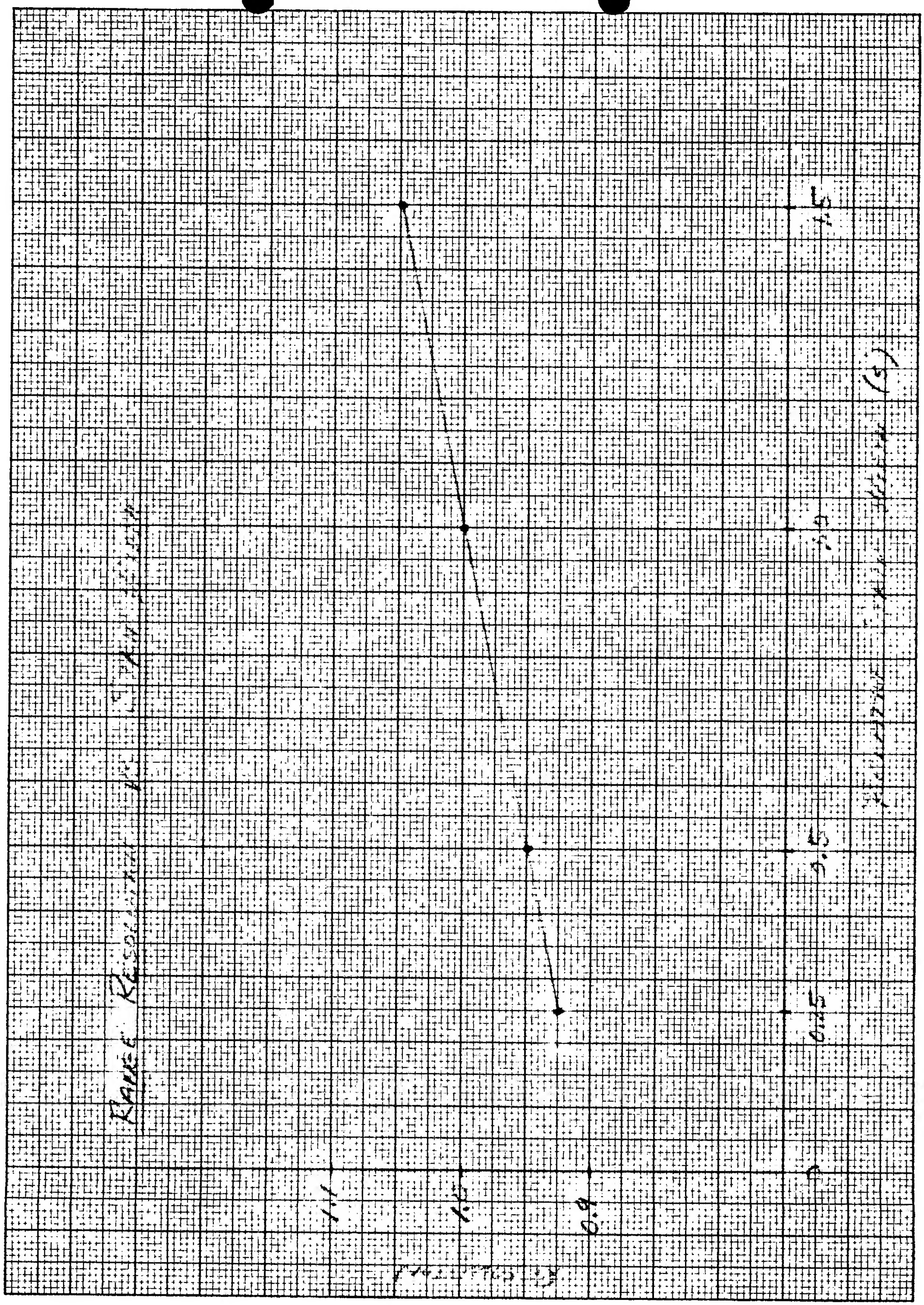

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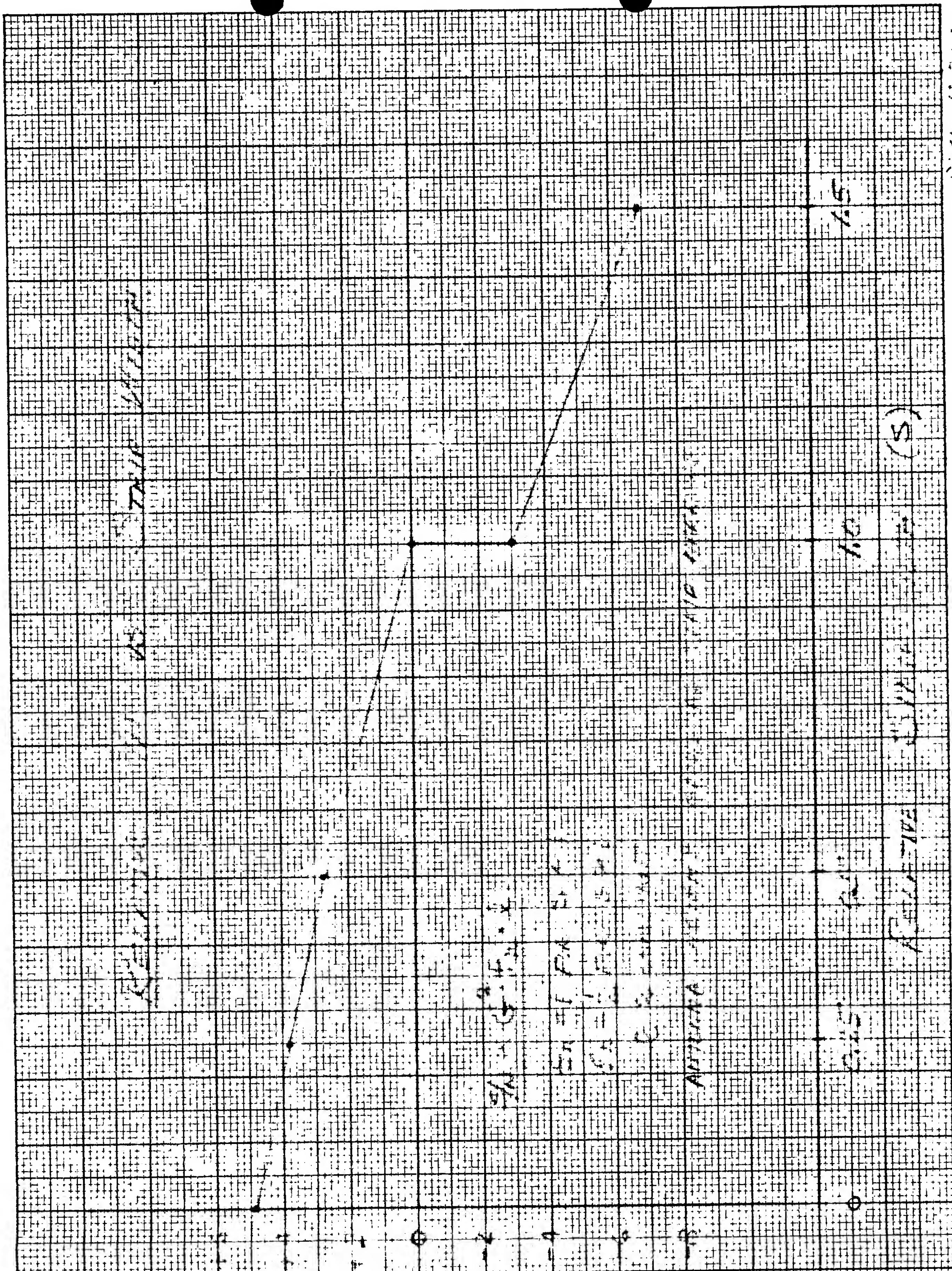

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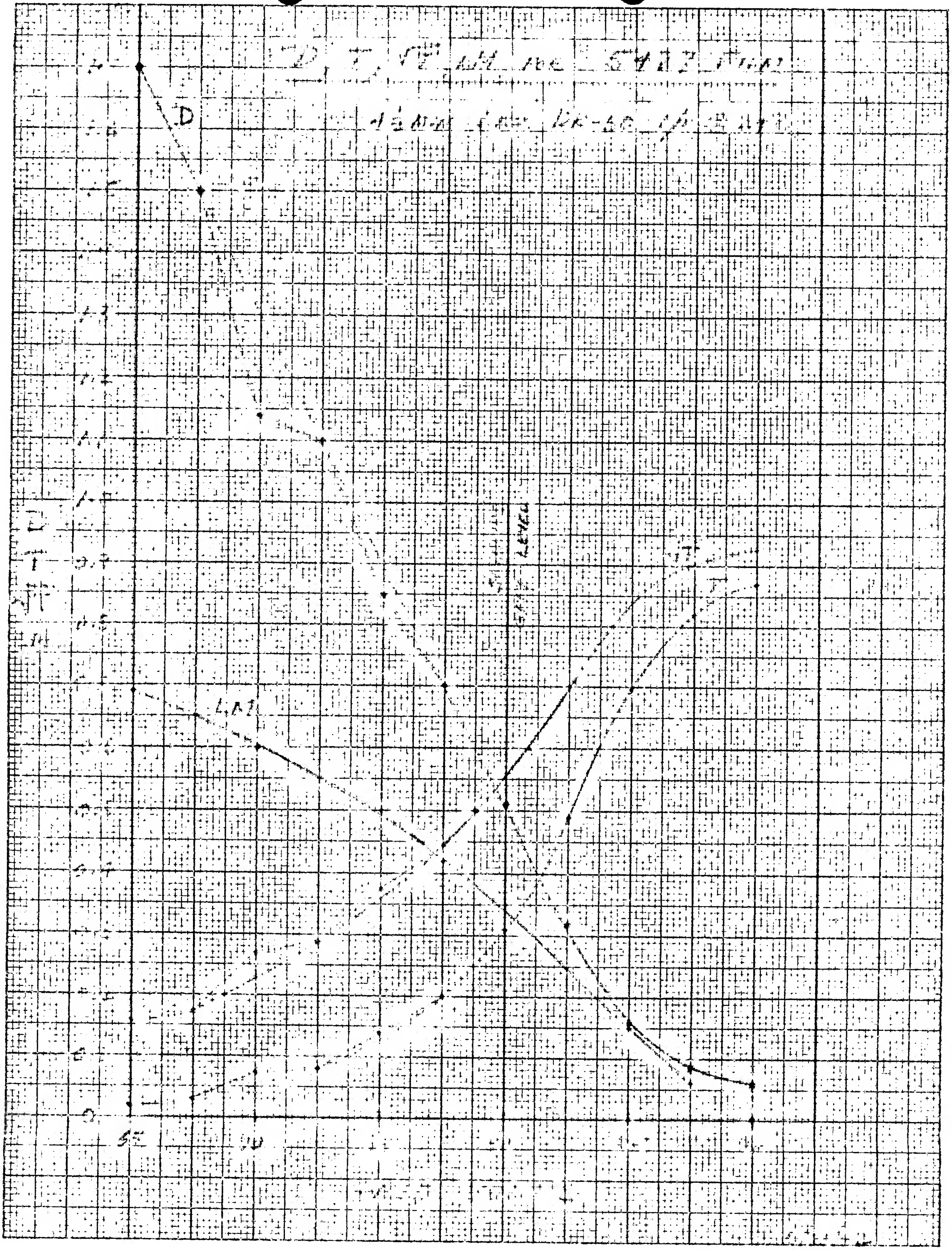

10 X 10 TO THE 1/2 INCH 359-12
KEUFFEL & ESSER CO. MADE IN U.S.A.

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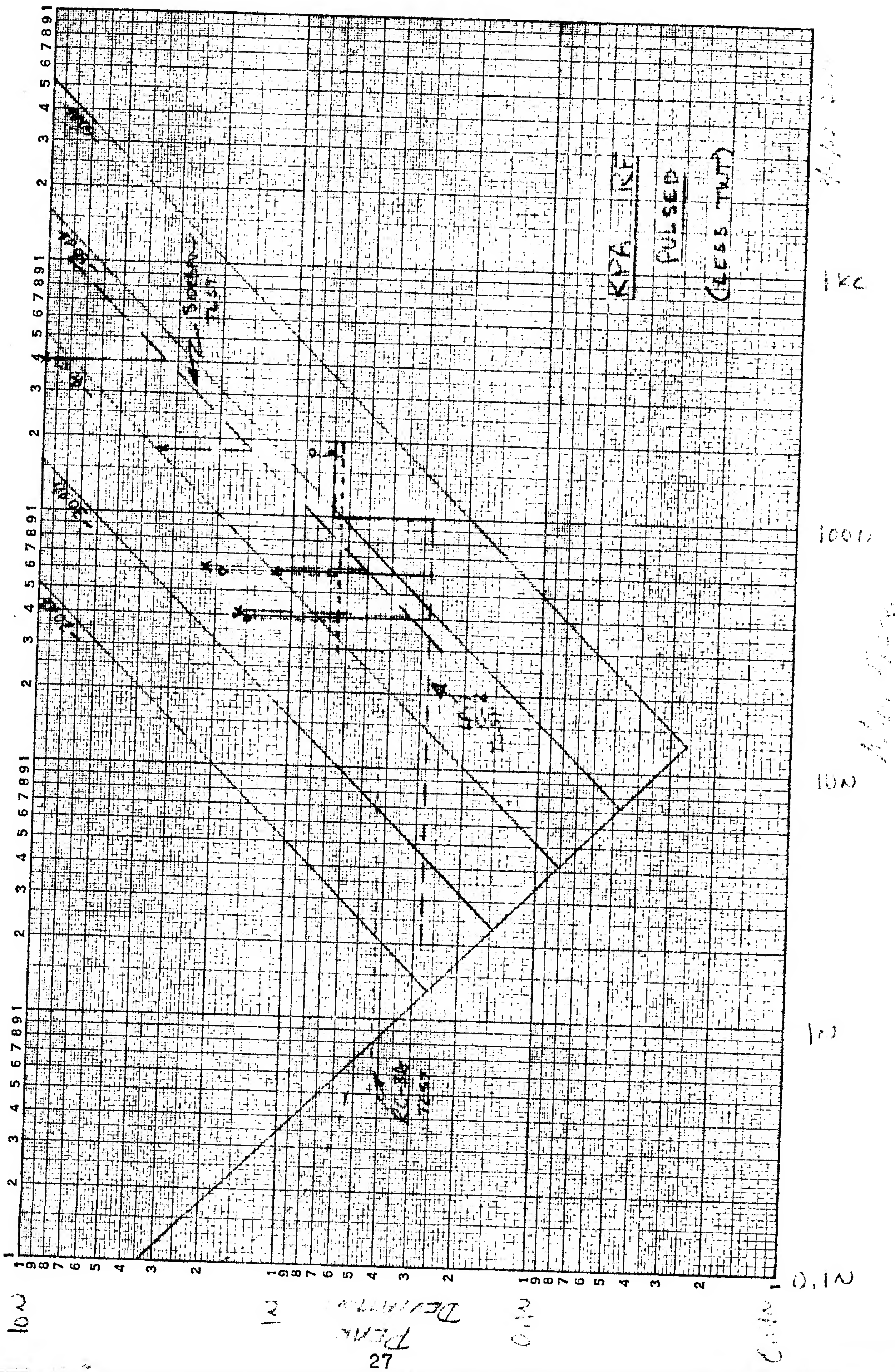

LOGARITHMIC 359-125G
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 X 5 CYCLES

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DESIGN EVALUATION ANALYTICAL TASKS

I. RESOLUTION

a. OPTIMIZATION OF RECEIVER BANDWIDTH AND SHAPE
b. RESOLUTION BUDGET
c. WAYS OF IMPROVING RESOLUTION FACTORS
d. DECIDE ON RESOLUTION DEFINITION
e. EFFECTS OF AGC, NON-LINEARITY, LIMITING ON RESOLUTION

II. TRANSFER CHARACTERISTIC

a. EFFECTS OF NON-LINEARITY ON CORRELATION
b. ADVANTAGES OF IF VS. VIDEO LIMITING
c. THEORETICAL $\sqrt{\text{TRANSMISSION}}$ VS. VOLTAGE; WAYS TO LINEARIZE
d. OPTIMUM GRAY LEVEL
e. EFFECTS OF HARMONICS AND SINE WAVES ON CORRELATION
f. TOLERABLE RANDOM GRAY LEVEL CHANGES
g. RECORDER EQUIVALENT CIRCUITS
h. SELECTION OF LIMIT LEVEL

III. S/N

a. STATISTICAL DISTRIBUTION OF NOISE AT OUTPUT
b. ATTAINABLE COHERENT INTEGRATION
c. ESTIMATE S/N REQUIRED FOR DETECTION
d. AVAILABLE S/N FOR DOPPLER TRACKER
e. S/N BUDGET; WAYS OF IMPROVING FACTORS

IV. SYSTEM

a. LIMITS ON INTRAPULSE AND INTERPULSE PHASE MODULATION
b. SELECTION OF OFFSET FREQUENCY
c. ALTITUDE-LINE CLUTTER
d. SIGNAL/CLUTTER FOR AREA AND POINT TARGETS
e. SINGLE-SIDEBAND IF RECEIVER
f. EQUIVALENT CIRCUIT OF RADAR-RECORDER-CORRELATOR

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S/N ESTIMATE

P_t = 1.5 MW

G = 31.5 DB

β_A = 0.75°

$\frac{c\tau}{2}$ = 15

NF = 8 DB

LOSSES (δ) = 9.6 DB

SHORT PULSE	0.2 DB	2 WAY
RADOME	2.0 DB	
STRUTS	1.5 DB	
WAVEGUIDE	0.5 DB	
DUPLEXER	1.3 DB	
FOLDING	3.0 DB	
WEIGHTING	1.1 DB	

r = −21 DB

Δf_{eff} 45 MC.

$$(S/N)_o = \frac{P_t G^2 \lambda^2 r \tan\theta \frac{c\tau}{2} 1 \beta_A f_r}{(4\pi)^3 KT \cdot NF \cdot \Delta f_{eff} \cdot \delta \cdot R^3 \cdot v}$$

$(S/N)_o \approx -4$ DB

4 DB LOWER THAN ORIGINAL ESTIMATE:

a. RADOME-STRUT LOSS: 3 DB GREATER

b. ANTENNA GAIN: 1 DB LESS

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RESOLUTION BUDGET

SOURCE	ORIGINAL		PRESENT		PREDICTED		COMMENTS
	RANGE	TRACK	RANGE	TRACK	RANGE	TRACK	
PULSE WIDTH	6	x	10	x	15	x	PULSE WIDENED TO: a. ACCOMODATE NEW TRANSMITTER b. IMPROVE S/N
RECEIVER RESPONSE	6	x	10	x	10	x	RECEIVER KEPT WIDE TO: a. IMPROVE RESOLUTION b. REDUCE RINGING c. IMPROVE S/N.
RECORDER	6	x	10	0		0	PREDICTED ASSUMES 1000-600 CYCLE PER INCH LIMITING PRESENT ASSUMES 600 CYCLE/INCH LIMITING
CENTER					12'		
EDGE					20'		
JITTER	x	x	2	x	2	x	
ACCELERATION	x	6	x		x		1. ASSUMES 0.2 g ACCELERATION 2. PRESENT ASSUMES NO MOTION COMPENSATION 3. PREDICTED ASSUMES 4 MILLI-GEE UNCOMPENSATED ACCELERATION
CENTER				28		5	
EDGE				28		15	
BEAM POINTING	x	6	x		x		
CENTER				3		3	
EDGE				7		7	
CORRELATOR	6	6	10	10	10	12':15'	PRESENTLY ACHEIVED
PHASE INSTABILITIES	x	x	x	4	x	4	EQUIVALENT TO 1.5 MILLI-GEE
ANTENNA PATTERN	x	6	x	4	x	4	$\ell_A/2$
RMS SUM	12	12	20				
CENTER				30	24'	14.5	
EDGE				30	27'	23	

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II. MOTION COMPENSATION

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ELEMENTS OF MOTION COMPENSATION

ANGLE CORRECTION

ANTENNA PIVOTED AT AFT END

YAW STABILIZATION ±3°

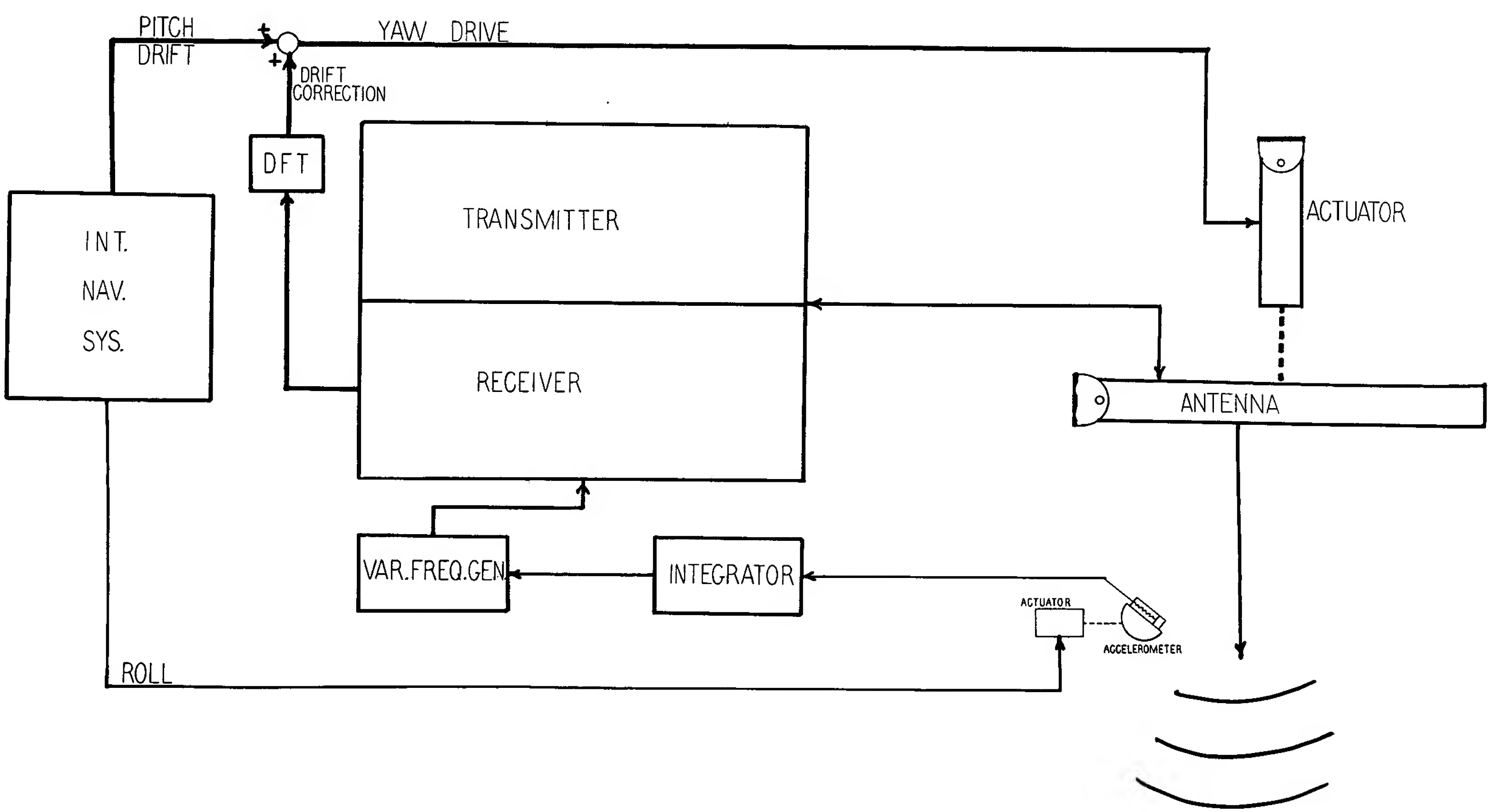
CORRECTS FOR PITCH AND YAW ERRORS

TRANSVERSE VELOCITY CORRECTION

ACCELEROMETER - ROLL STABILIZED

INTEGRATION TO GIVE VELOCITY

CONTROLS VARIABLE FREQUENCY GENERATOR



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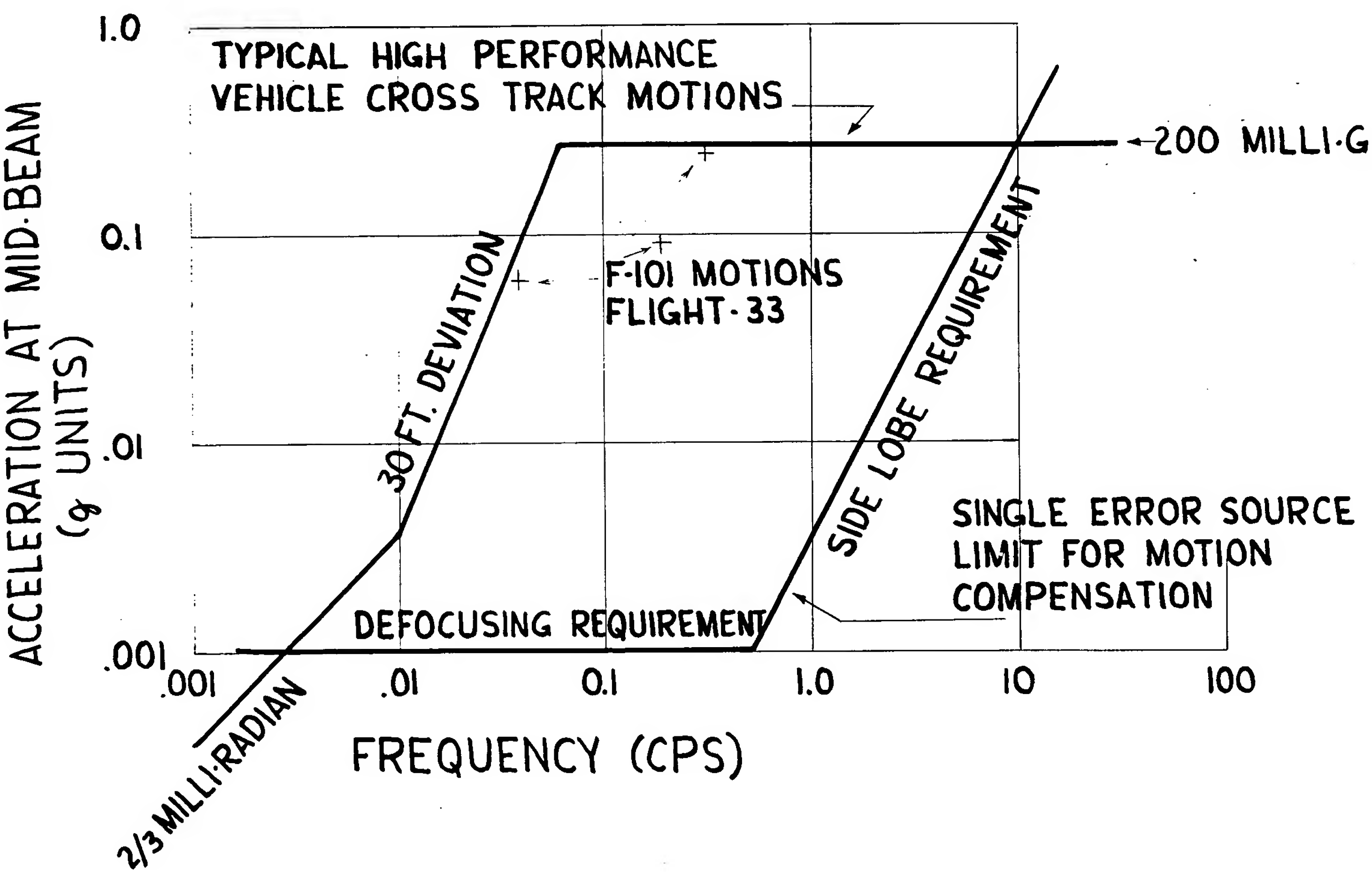
CROSS TRACK MOTIONS AND LIMITATIONS



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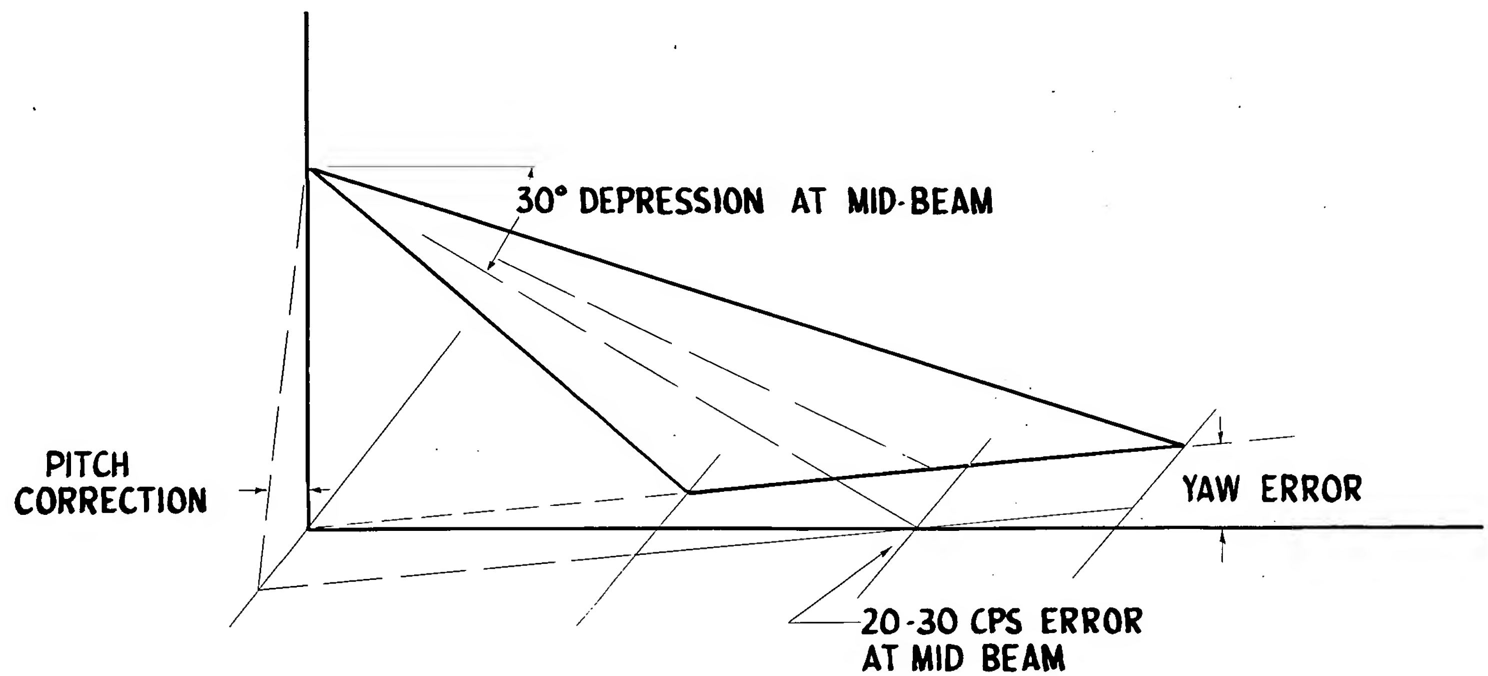
FLIGHT TEST ANGLE COMPENSATION



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ANGULAR ERROR-FLIGHT TEST-PREDICTED

	ANGLE DEGREES	RESIDUAL DEGREES	DOPPLER-CPS BEAM CENTER	DOPPLER-CPS BEAM EDGE
ANGLE OF ATTACK	±0.5	±0.1	±25	±25
WIND DRIFT	±3.0	–		±480
PITCH	±1.0	±0.1	±25	±25
YAW	±0.25	–		±40

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TRANSVERSE MOTIONS IN FLIGHT-33

AXIS	AMPLITUDE DEGREES	PERIOD SECOND	ACCELERATION g	VELOCITY FT/SEC	CALCULATED DOPPLER CPS	MEASURED DOPPLER CPS
YAW	±0.2	3	±0.20	±3.0	±60	–
YAW	±0.2	7	±0.084	±3.0	±60	–
PITCH	±1.0	25	±0.067	±8.6	±170	±50

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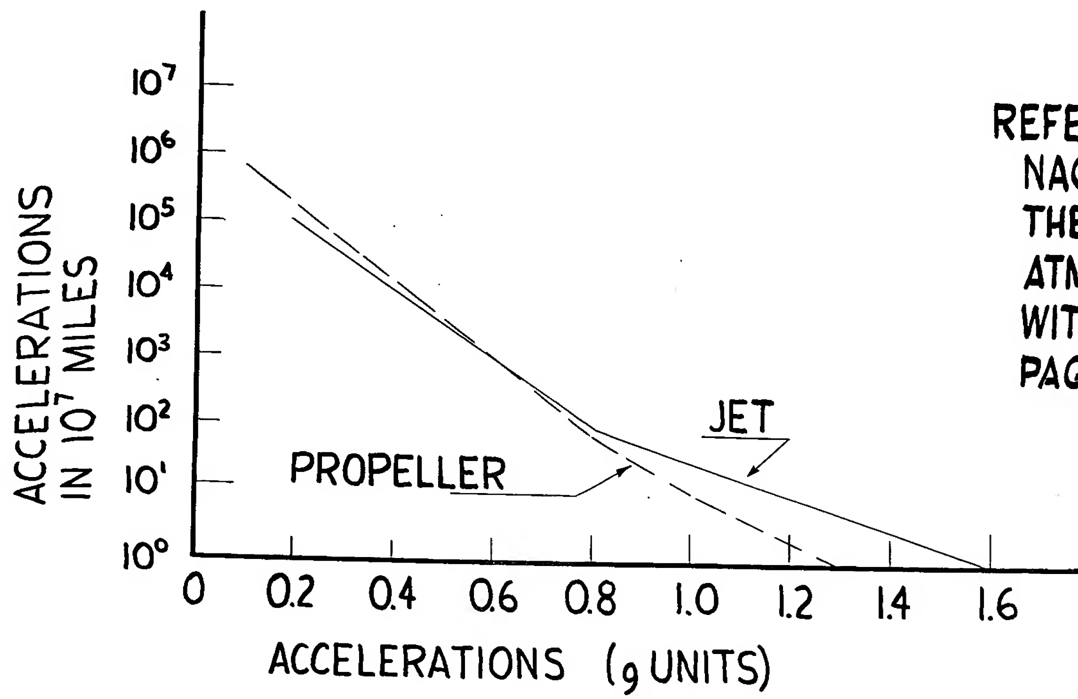
VERTICAL ACCELERATIONS IN AIRLINE OPERATION



REFERENCE:
NACARM L53G15A
THE VARIATION OF
ATMOSPHERIC TURBULENCE
WITH ALTITUDE
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III. ANTENNA DEVELOPMENT

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ANTENNA GAIN - 100^{IN} LENGTH

MAXIMUM THEORETICAL GAIN FROM AREA $= \frac{4\pi A}{\lambda^2} = \frac{4\pi \times 100 \times 10}{(1.25)^2} =$ 39.1 DB

LOSSES

ELEVATION PATTERN SYNTHESIS $CSC^2\theta\ COS^{\frac{1}{2}}\theta$		3.28	
AZIMUTH PATTERN SYNTHESIS ORIGINAL 0.9 FOR TAYLOR DISTRIBUTION		.5	
I^2R LOSSES		2.5	
POWER DIVIDER	1.0		
MANIFOLD	.5		
MATCHED LOADS	.5		
STICK & COVERS	.5		
	2.5		
ALLOWANCE FOR TOLERANCE, OMITTED RADIATORS		1.0	
		7.3	- 7.3
REASONABLE SPEC GAIN			31.8 DB

PRESENT BONDING IS CAUSING ADDITIONAL LOSS OF 1.5 DB INTO MATCHED LOADS

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IV. SYSTEM UNITS

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RESONANT RING IMPROVEMENT

		GOAL	MEASURED
1. ORIGINAL UNIT		0.5-1.0 MEG W.	0.23 MEG W.
		10 NANOSEC.	10 NANOSEC.
		20-40 W. AVGE.	9.2 W. AVGE.
2. LIMITING FACTORS	DRIVING POWER		
	LOSSES IN RING		
3. IMPROVEMENTS	RING LENGTH INCREASED		0.14 MEG W.
			20 NANOSEC.
	TUNING SHORTS IMPROVED		12.3 W. AVGE.
4. FURTHER IMPROVEMENTS	INCREASE RING LENGTH (FOLD)	0.40 MEG W.	
		30 NANOSEC.	
	INCREASE DRIVE POWER	48 W. AVGE.	

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TABLE - I
TRANSMITTER PERFORMANCE

	PRESENT PERFORMANCE	PDS 21219	EXPECTED 4/15/63	POSSIBLE 12/63
A. TRANSMITTER				
1. FREQUENCY	9450	9400	9400	9400
2. PULSE WIDTH	40 NS	30 NS	30NS	20 NS
3. PRF				
4. SIZE				
5. WEIGHT	* 240 LBS.	-	* 210 LBS	
B. SFD-24 CFA				
1. PEAK POWER	600 KW	1.0 MW	1.25 MW	2.0 MW
2. AVERAGE POWER				
3. EFF. (FINAL AMP.)		40%	40%	40-55%
4. GAIN	16DB	18 DB	19 DB	20 DB
5. PHASE STABILITY	<1.5°	-	<3°	< 5°
6. WEIGHT	45 LBS	45 LBS	38 LBS	40-50 LBS
7. COOLING	Liquid	Gas	Gas	Gas

*ESTIMATED

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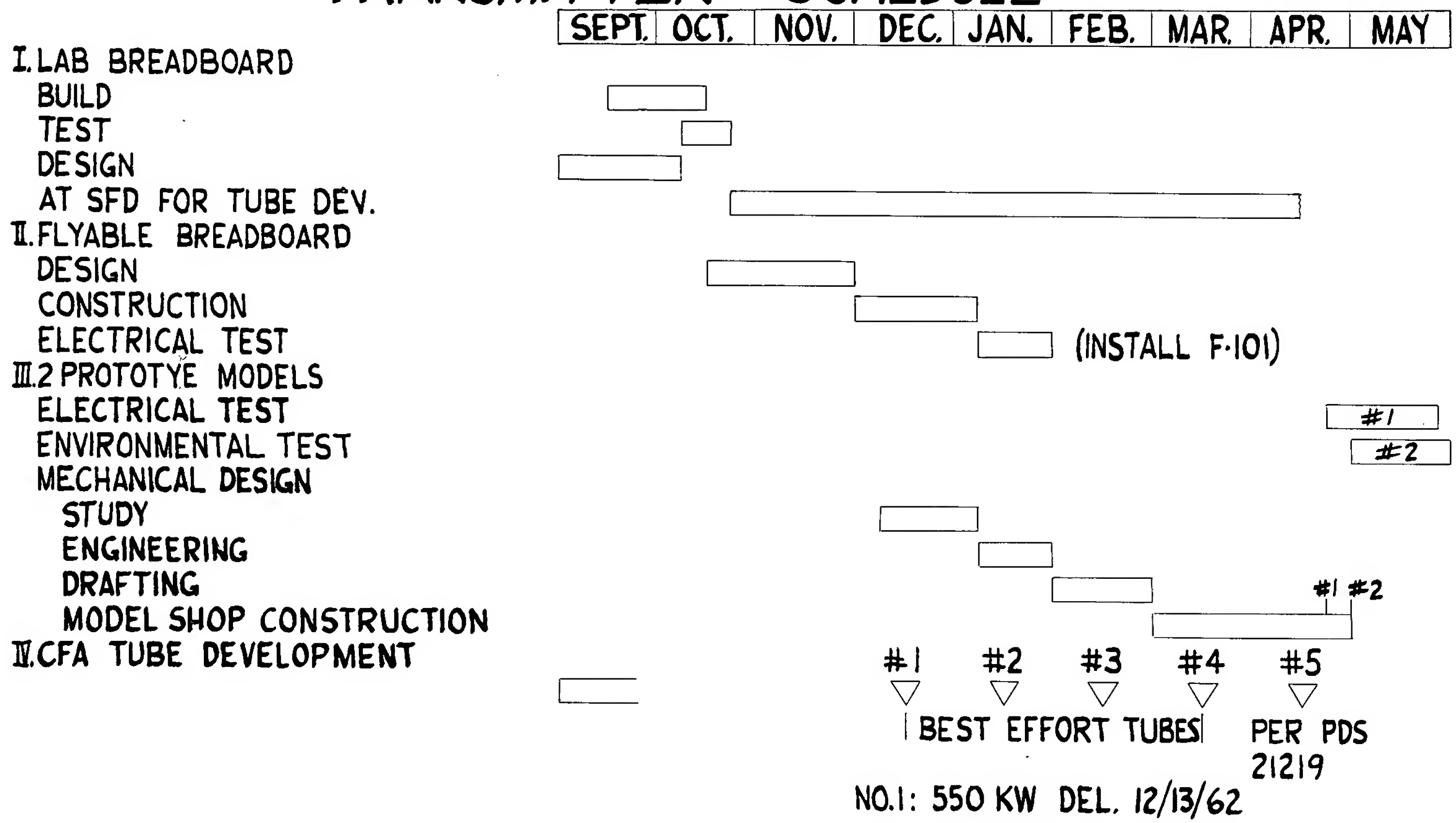
TRANSMITTER SCHEDULE



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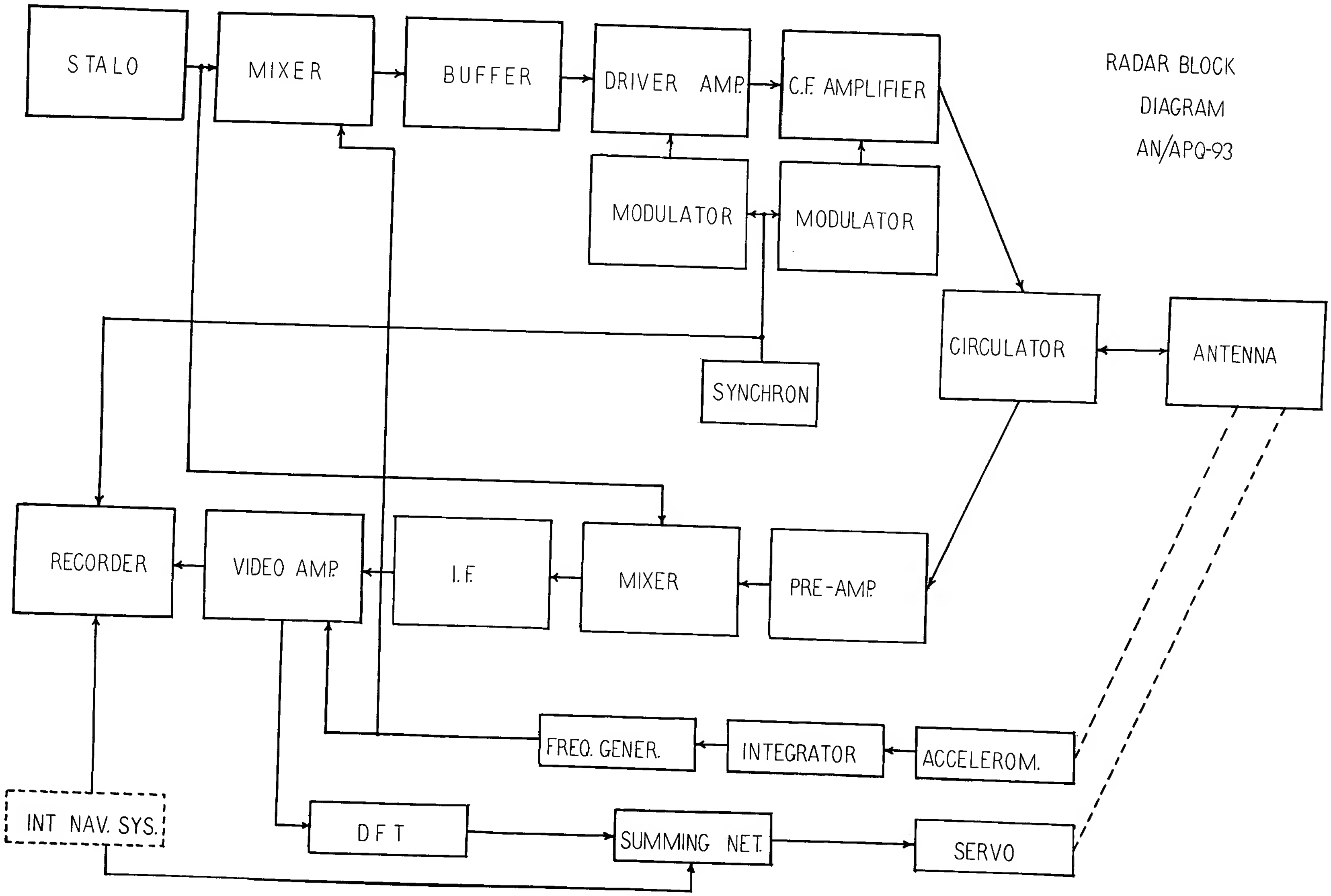
RADAR BLOCK DIAGRAM AN/APQ-93



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RADAR PARAMETERS

11/28

TRANSMITTER

FREQUENCY	9400 Mc
PEAK POWER	10^6 WATTS
PULSE WIDTH	30×10^{-9} SEC.
PRF	3927
AVERAGE POWER	118 WATTS

RECEIVER

NOISE FIGURE (TWT PREAMP)	7.5 db
DUPLEXER & LINE LOSSES	2.1 db
CIRCULATOR – 0.25 db (ONE WAY)	
TWT PROTECTOR – 0.4 db	
WAVEGUIDE – 0.65 db (ONE WAY)	
STALO FREQUENCY	9280 Mc
I-F	120 Mc
I-F AMP. BANDWIDTH	60 Mc
VIDEO AMP BANDWIDTH	47 Mc
IMAGE FILTER BANDWIDTH	70 Mc
IMAGE REJECTION	
COHO REF. OFFSET FREQ.	400 cps

ANTENNA

FREQUENCY	9400 Mc
GAIN	31.5 db
AZ BEAMWIDTH	0.75 DEG.
EL BEAMWIDTH	20 DEG.
EL PATTERN	$\csc^2 \cos^{1/2}$
AZ SIDELOBE	–14 db
EL SIDELOBE	–15 db
EL IMAGE PATTERN	–15 db
VSWR	1.3
RADOME LOSS (ONE WAY)	1.75 db

RECORDER

FILM SPEED	2.0"/SEC NOM.
CONTROL RANGE	±10%
CONTROL ACCURACY	0.1%
FILM CAPACITY	250' × 9.5"
CRT SPOT SIZE	0.0005"
SWEEP SPEED	1.02 Mu/30×10^{-9} SEC
TRACK FREQ.	900 cps (MAX.)

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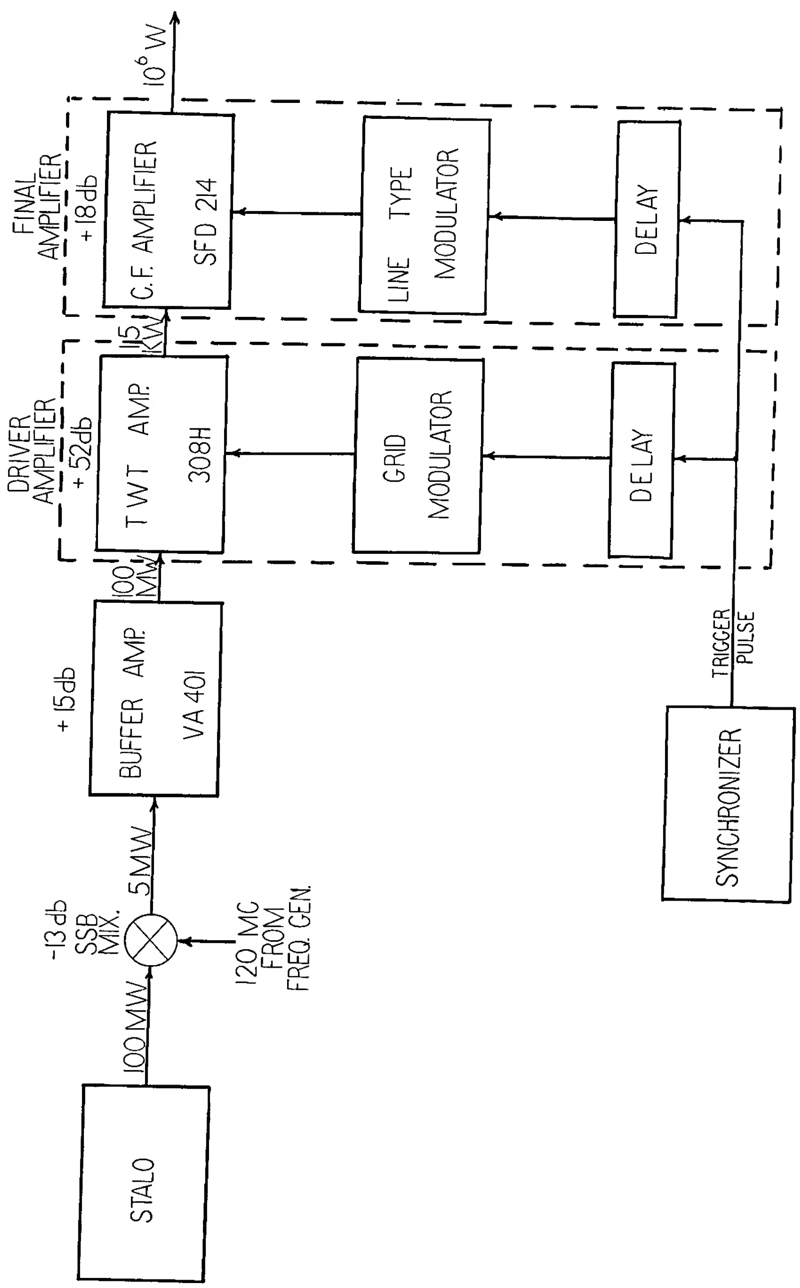
TRANSMITTER



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SYSTEM WEIGHT

TRANSMITTER	210 *	SYSTEM FRAME	45 *
RECEIVER	27	FRAME TRUSS	30
TWT PREAMP	11	AUXILIARY RECORDER	6
RECORDER	175 *	PRESSURE SYSTEM	15
VIDEO AMPLIFIER	3	TOTAL	96
SYNCHRONIZER	25		
NAV-TIE-IN	20 *		
POWER SUPPLY	70		
CONTROL PANEL	2		
ANTENNA	140 *		
TOTAL	683		

TOTAL WEIGHT - 779

* ESTIMATED WEIGHT

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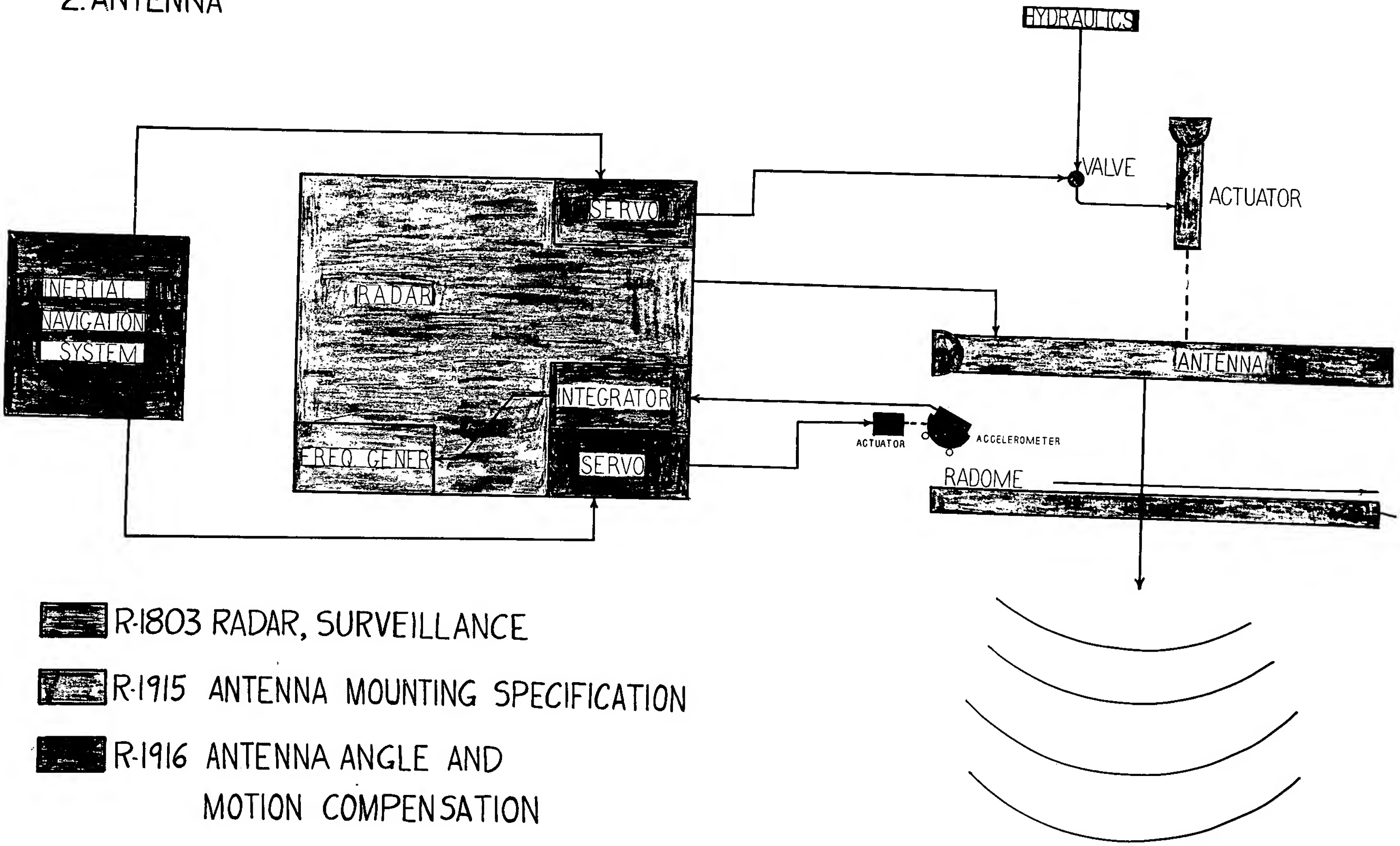
INSTALLATION

1. RADAR ASSEMBLY
2. ANTENNA



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V. FLIGHT TEST PROGRAM

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FLIGHT COMPARISON

PARAMETER	FLIGHT S-11	FLIGHT S-33
PULSE WIDTH	10 NANO-SECOND	20 NANO-SECOND
POWER OUTPUT	2.5 WATTS AVERAGE	9.0 WATTS AVERAGE
NOISE FIGURE	10.1 DB	9.6 DB
OFFSET CORRECTION	MANUAL OR DRIFT CORRECTION BY CONTROL OF VARIABLE FREQUENCY OSCILLATOR	MANUAL ONLY
HOLOGRAMS	PASS THROUGH ZERO	PASS THROUGH ZERO
ANTENNA	VERTICAL GYRO PITCH STABILIZED	STIFFENED MECHANICALLY, DFT STABILIZED FOR YAW AND PITCH BY PITCH CORRECTION
RECORDER	FIBER OPTICS	LENS OPTICS, NEW SHOCK MOUNTS, LENSES STIFFENED MECHANICALLY
PRIMARY FILM:		
RANGE SPOT SIZE	12 MILS	5 MILS
HIGHEST HOLOGRAM FREQUENCY	150 CPS	250 CPS
CORRELATED FILM SPOT SIZE	20 MILS RANGE (73) 15 MILS AZIMUTH (50)	11 MILS RANGE (35) 8 MILS AZIMUTH (25)

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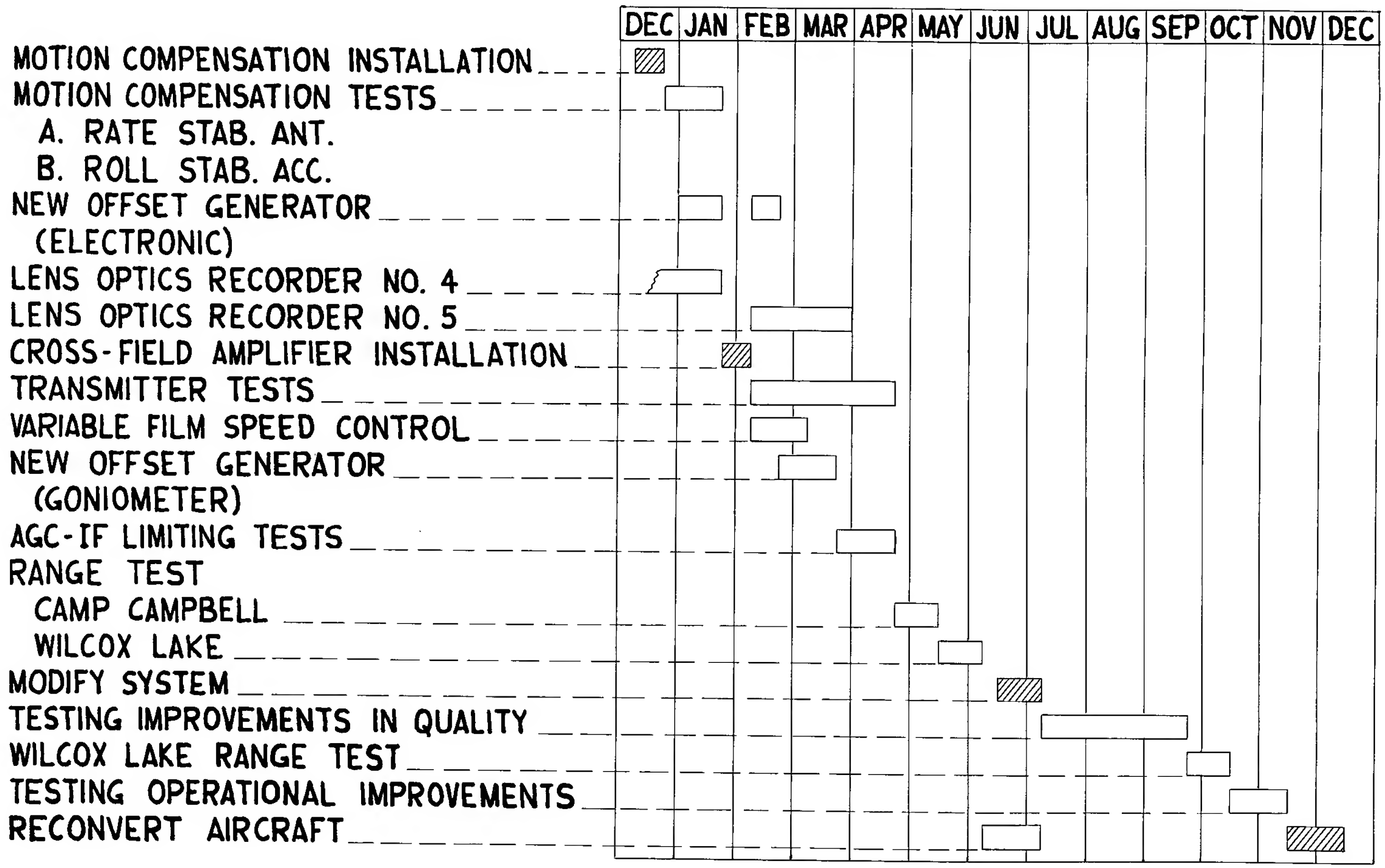
FLIGHT TEST SCHEDULE FOR 1963



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FLIGHT TEST PLAN

FLIGHT NO. 34	FLIGHT NO. 35	FLIGHT NO. 36
I. PURPOSE TEST MOTION COMPENSATION SYSTEM	I. PURPOSE TEST EFFICACY OF M.C. AND VARIOUS OFFSET FREQUENCIES	I. PURPOSE TEST M.C. AT HI-MACH, HI-ALT., & LOW S/N
II. METHOD RUN-1: M.C. WITH 200 CPS OFFSET RUN-2: DFT CONTROL, NO M.C., 200 CPS OFFSET RUN-3: 200 CPS OFFSET, DELETE DFT	II. METHOD RUN-1: M.C. WITH 200 CPS OFFSET RUN-2: MANUAL MODE, 200 CPS OFFSET RUN-3: ZERO OFFSET, M.C. AND MANUAL	II. METHOD RUN-1: M.C. WITH 200 CPS OFFSET RUN-2: MANUAL MODE 200 CPS OFFSET RUN-3: ZERO OFFSET, M.C. AND MANUAL
III. FLIGHT PARAMETERS ALTITUDE: 20,000 FT. VELOCITY: 585 KNOTS S/N: + 5 DB VELOCITY VECTOR: DOWNWIND	III. FLIGHT PARAMETERS ALTITUDE: 20,000 FT. VELOCITY: 585 KNOTS S/N: + 5 DB VELOCITY VECTOR: DOWNWIND	III. FLIGHT PARAMETERS ALTITUDE: 40,000 FT. VELOCITY: 830 KNOTS S/N: −5 DB VELOCITY VECTOR: DOWNWIND
IV. ANCILLIARY DATA A- ROTATE A/C IN THREE AXES B- RECORDER RESPONSE C- BALANCED RECORDER ACCELERATIONS	IV. ANCILLIARY DATA A- ROTATE A/C IN THREE AXES B- RECORDER RESPONSE C- BALANCED RECORDER ACCELERATIONS	IV. ANCILLIARY DATA A- ROTATE A/C IN THREE AXES B- RECORDER RESPONSE C- BALANCED RECORDER ACCELERATIONS
V. INSTRUMENTATION ADD RATE GYRO AND STABILIZED ACCEL. TO EXISTING	V. INSTRUMENTATION ADD RATE GYRO AND STABILIZED ACCEL. TO EXISTING	V. INSTRUMENTATION ADD RATE GYRO AND STABILIZED ACCEL. TO EXISTING

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RESUME´ OF FLIGHTS TO DATE (1961-1962)

NOVEMBER	4 PILOT CHECK-OUT FLIGHTS
	2 AUTOPILOT CHECK-OUT FLIGHTS
DECEMBER	DOWN FOR MODIFICATION AND INSTALLATION
JANUARY	DOWN FOR MODIFICATION AND INSTALLATION
FEBRUARY	3 PILOT CHECK-OUT FLIGHTS
	1 SYSTEM FLIGHT
MARCH	2 PILOT CHECK-OUT FLIGHTS
	2 SYSTEM FLIGHTS
APRIL	4 SYSTEM FLIGHTS
MAY	5 SYSTEM FLIGHTS
	1 PILOT PROFICIENCY FLIGHT
JUNE	6 SYSTEM FLIGHTS
	1 PILOT PROFICIENCY FLIGHT
JULY	2 SYSTEM FLIGHTS
	1 PILOT PROFICIENCY FLIGHT
AUGUST	4 SYSTEM FLIGHTS
	2 PILOT PROFICIENCY FLIGHTS
SEPTEMBER	2 SYSTEM FLIGHTS
	1 PILOT PROFICIENCY FLIGHT
OCTOBER	3 SYSTEM FLIGHTS
	2 PILOT PROFICIENCY FLIGHTS
NOVEMBER	2 SYSTEM FLIGHTS
	1 PILOT PROFICIENCY FLIGHTS
DECEMBER	DOWN FOR MODIFICATION
TOTAL	51 FLIGHTS
	33 DATA FLIGHTS
	10 HAD IN FLIGHT FAILURES

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VI. ENVIRONMENTAL TEST PROGRAM

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ENVIRONMENTAL TEST

1. RADIO INTERFERENCE (SYSTEM) .... NO SUSCEPTABILITY
   .... MINOR RADIATION
2. EXPLOSION (SYSTEM) ✓
3. VIBRATION

RECEIVER	✓	
SYNCHRONIZER	✓	
NAV. TIE-IN	✓	
POWER SUPPLY	✓	
MODULATOR	✓	
DUPLEX. DRIVER	✓	
RESONANT RING	—	MTG BRACKET FAILED, CORRECTED. RECHECK
TWT		NOISE FIGURE DETERIORATED. RECHECK
RECORDER		MOVEMENT OF LENS, MIRROR

SPECIAL INVESTIGATION
10, 20 ~ FROM POD
120, 160 ~ FROM ENGINE

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4. CRASH SAFETY (SYSTEM) PLANNED
5. TEMP. ALTITUDE (SYSTEM) PLANNED

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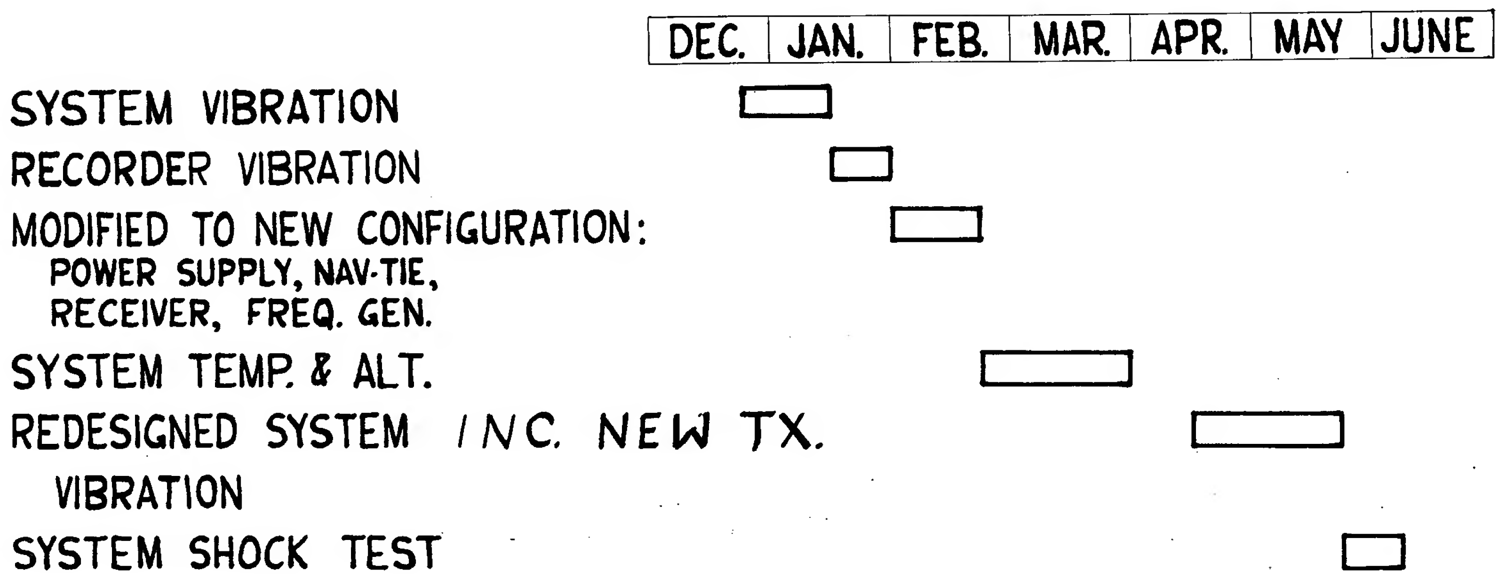
ENVIRONMENTAL TEST SCHEDULE



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